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About 96 per cent of all United States-built automobiles are now using tempered safety glass in side windows. This change has occurred over the last four years with Chrysler, American Motors and Studebaker starting the trend in 1957, Ford following in 1958-59 and General Motors in 1959-60. All cars of late 1960 and current 1961 models, except some models of Cadillac, are equipped with tempered safety glass.
Because of the strong interest in tempered safety glass in automobiles, members of the Federal Safety Council held a special meeting in Washington, D.C., on January 24 to review the relative merits of laminated and tempered safety glass for use in automobiles. Some of the technical experts and executives from the American Standards Association, Automobile Manufacturers Association, major glass companies and automobile companies presented a detailed demonstration of the properties of safety glass which affect the use of these materials in motor vehicles.

Properties of Safety Glass Demonstrated

ABOUT 120 persons were in the audience; some were representatives from such governmental divisions as the General Services Administration, Interstate Commerce Commission, and the National Safety Regulations Board; many others were present in view of their concern with the public safety.

As Program Chairman, Karl M. Richards, Manager of Field Services for Automobile Manufacturers Association outlined the history of safety glass use in automobiles and especially commented that the trend toward increased use of tempered safety glass has resulted in unwarranted attacks by commercial interest groups through claims that the safety of the motoring public is in jeopardy. This, he said, makes a presentation of facts gathered by leaders in the automotive world both desirable and necessary. As a prelude to actual demonstrations by technical experts, Mr. Richards pointed out that lack of uniform legislation regarding safety glazing materials in the 50 states comprising our country would result in chaos and confusion, and he called on Cyril Ainsworth, Deputy Managing Director of American Standards Association for many years, to explain further the part played by A.S.A.

Mr. Ainsworth summarized the development of the American Standards Safety Code for Safety Glazing Materials for Glazing Motor Vehicles Operating on Land Highways, Z26.1-1950, which is used as a basis for legislation in many states, and as a standard of comparison and testing by administrators in nearly all states.

This code evolved over several years between 1932 and 1938, when it was approved in substantially its present form, and includes tests considered appropriate for all safety glazings, among them, laminated, tempered and wire glass, as well as plastic materials. This code is periodically revised, but the major tests have been approved over and over again as being the most suitable tests to bring out the physical properties of the material being considered.

Dr. J. Ryan, Research and Development Director of Libbey-Owens-Ford Glass Company, and one of the original members of the American Standards Associ-

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1961 Bleininger Award

Eugene Cornelius Sullivan

ONE of the foremost pioneers of organized research in glass, Eugene Cornelius Sullivan, will receive the Albert Victor Bleininger Memorial Award on March 10 from the Pittsburgh Section of the American Ceramic Society. This tribute will honor Dr. Sullivan as a scientist, administrator, humanitarian, and as a man whose deep understanding of industrial research has endowed him throughout his life with the ability to inspire others. He has always been one of the first to offer encouragement to a young chemist or physicist in suggesting an idea for developing a new glass formula, devising a new glass-melting method of finding some new use for glass.

His first encounter with glass research was in 1908, when he became associated with Corning Glass Works as chief chemist, at a time when there was very little, if any, formal research in glass. He has never been separated from glass, or from Corning, since that time, and even today, at 89 years of age, he visits his ninth floor office daily in the Houghton Park headquarters. At a moment's notice, he will recall dates and places associated with Corning's research and development program over the past half-century. Dr. Sullivan takes an active interest in current developments and is constantly projecting programs for the future. He drives his own car to work, and regularly visits the Corning Country Club in the summer to watch company associates play his once-favorite sport of golf.

He began work at Corning with one assistant and 1200 square feet of laboratory space on the fourth floor of a factory building (technical staff in 1961: 460 chemists, physicists, engineers, glass technologists and assistants). After organizing the laboratory and staff, he became vice-president and director of research, and, in 1921, vice-president, of manufacturing. In 1928 he became president of the company for one and a half years—the short tenure of office being at his own insistence, because he wanted to return to his first love: glass research. And so, in 1930, he became vice-chairman of the board of directors and special advisor to the president and the board on all major company developments. His work and interests drew him so closely to

Amory Houghton, Jr. (left), Corning staff vice-president, and Dr. Eugene Cornelius Sullivan.

the laboratory he had founded that it was very logical and essential for him to head that organization again — which he did in 1937 as director of research of the Corning Glass Works. He held this position until 1946 when he was made honorary vice-chairman of the board of directors; in 1950, he became honorary chairman.

Dr. Sullivan has always been active in the civic affairs of Corning, New York, and is a former director and a founder of the Corning Country Club and a former member of the Corning Library Board. He served for 36 years as a member of the Corning, New York, Board of Education and for many years as Board vice-president. He was especially interested in the selection of books, primarily for science classes, and is still very much interested in city educaton work, having a year ago willed his large home to the newly organized 2-year Corning Community College.

Other business positions he holds are Honorary Chairman of the Board, Dow Corning Corp.; vice-president and director, Corhart Refractories Co.; director Pittsburgh Corning Corp.; director, Societie Industrielle des Silicones; trustee, Corning Glass Works Foundation; and director, The Corning Museum of Glass.

He was educated in Chicago schools and later attended the University of Michigan, where he received his B.S. degree in Chemistry in 1894.

He holds an Honorary Sc.D degree from the University of Michigan, the Perkin Medal of the Society of Chemical Industry, the Industrial Pioneer Award and, in 1928, received jointly with the late Dr. William C. Taylor, also of Corning, the Howard N. Potts Medal of the Franklin Institute. He holds eight patents in the glass field and is author and co-author of more than a dozen publications.

A Fellow of the American Ceramic Society, he has been a member since 1917, and is an Honorary Fellow of the Society of Glass Technology, member of the American Chemical Society, Electrochemical Society, and other scientific organizations, and he has served on various advisory boards, including Chairman of the Advisory Subcommittee of Glass of the U.S. Bureau of Standards, as well as being an active and interested member of the Directors of Industrial Research.

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The Bleininger Award is presented each year by the Pittsburgh Section of the American Ceramic Society for "distinguished achievement in the field of ceramics."

Conditions of Glass Formation Among Simple Compounds* IN FOUR PARTS Part IV

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Some Manifestations of Our Approach to Glass Formation

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I. Introduction

● OUR KINETIC APPROACH revealed that two different principles can be responsible for glass formation. The most obvious principle, that of "complexity" is very evident in organic chemistry.

The second principle of glass formation is the absence of flaws. We use the word "flaw" in the sense that it comprises places in the structure which introduce a major asymmetry of forces. We showed that asymmetries in a structure cause a disproportionation of the binding forces which increases the mobility and aids nucleation.

On the basis of our approach to glass formation we could answer some fundamental questions:

1. Why is it not possible to make glasses which have a much higher softening temperature than silica glass? Contrary to the predictions of V. M. Goldschmidt no glasses of high melting carbides, borides, and nitrides have been reported. No known glass seems to have a higher softening temperature than silica.

2. What causes the chemically and structurally similar oxides V_2O_5 and P_2O_5 to behave fundamentally differently with respect to glass formation?

3. Why do all additions to vitreous silica, e.g., Na_2O, CaO, or Al_2O_3, increase its devitrification rate whereas combinations such as $Na_2O + Al_2O_3$ or $Na_2O + B_2O_3$ make it possible to obtain stable glasses?

Now we are in a position to answer the fundamental question of the vitreous state; namely, how is it possible that substances which are so very different, e.g., selenium, glycerol, organic polymers and silicates, resemble one another closely in their glassy state with respect to the change of volume, viscosity or specific heat with temperature? The same substances in their crystalline states have nothing in common.

It is the object of this paper to point out some of the consequences of our approach to glass formation with respect to the constitution of glass, in particular to present a new viewpoint on the thermal expansion of glasses.

II. Structures of Liquids as Represented by Three Extreme Models

We shall approach the structures of liquids in the same way as we approach gases and crystals. We use the concept of "ideal" gases and crystals as a basis for description and later point out its limitations and add refinements. We will do the same for the liquid structures. We cannot expect the resulting "ideal" pictures to be identical with the real liquid structures but they will provide a basis for discussion and for adding refinements where needed.

1. The Bernal Model

J. D. Bernal[1] concerned himself with the geometry of

* Mineral Industries Contribution No. 59-95

monoatomic liquids, but he pointed out that it would be possible to build a theory for ionic liquids on the same basis, provided that one takes into consideration the opposite signs of the component ions and their radii. The condition for an ionic liquid is that the charges should be evenly distributed so as to balance one another and ionic liquids should obey statistically the same rules which hold for ionic crystals.

Bernal describes his liquids as homogeneous, coherent, and essentially irregular assemblages of molecules which contain no crystalline regions or holes which are large enough to admit another molecule. The most characteristic feature of Bernal's model is that the irregularity of a liquid is the result of a very small concentration of atoms which show a slight departure from the normal coordination number. Starting out with a regular close-packed hexagonal planar aggregate Bernal was able to show that if in one place the coordination changes from 6 to 7 or to 5, the configuration of the whole array becomes irregular and it is practically impossible to return to a regular arrangement within an area which contains less than 100 atoms. The irregular area is characterized by a variation of distances. Bernal describes his liquids by the coordination number and an irregularity function. Bernal's model resembles closely a perfect crystal because it is essentially free of flaws or holes. Therefore, we will refer to Bernal's model as a "flawless" liquid.

The condition which causes this "flawless" arrangement of atoms to be liquid is that the thermal energy is of the same order of magnitude or greater than the chemical binding forces. The environment of molecules in a liquid is necessarily in continual flux thus providing a mechanism for self diffusion and fluidity.

In applying Bernal's model to ionic liquids we should add that the continual flux does not need to involve place exchanges between anions and cations. As explained earlier we prefer to think that in such a flawless liquid the anions are mobile within the anionic part and the cations within the cationic part of its structure.

Silica above 1710°C forms such a flawless liquid which resembles closely the high temperature form of cristobalite. Bernal's model describes a liquid which resembles closely the crystal from which it has formed. Slightly above the melting point of the crystal, a melt which corresponds to Bernal's model should be very viscous. Such a melt should be easily changed into a glass on cooling. We do not need to go into the geometrical details to which Bernal directs most of his attention, because we are primarily interested in glasses which have tetrahedral and octahedral structures.

2. *The Frenkel Model*

Another extreme structure of a liquid is described by J. Frenkel[2]. According to his model the homogeneity of a liquid is only an apparent one. According to Frenkel a liquid is permeated by a large number of surfaces of rupture which do not develop into microscopic size and which are dynamic in nature. These fissures are spontaneously closed in certain places while new ones form in neighboring regions. At any given instant, however, the whole volume of the liquid contains a system of cavities in the form of holes and cracks. We will refer to Frenkel's model as a "fissured" liquid. Frenkel speaks of "heterophase fluctuations" and "cavitation fluctuations." The usual thermodynamic treatment of liquids deals with average values of different quantities which are integrated over long time intervals. From the thermodynamic point of view the Frenkel model gives the same results as one which is based on a general increase of the intermolecular distances and which operates with ordinary density fluctuations. However, if one is interested in the instantaneous and not the average distribution of the molecules within a liquid, Frenkel considers that the concept of a uniform distribution is substantially incorrect.

In contrast to Bernal's model of a "flawless" liquid the Frenkel model of a fissured liquid bears no similarity to the crystal. Even just above the melting point of a crystal one cannot speak of lattices and vacancies in the sense that we use these terms in describing defective crystals.

When we derived the structural changes which must take place in a sodium chloride crystal during its melting[3] because of the disproportionation of all binding forces into weaker and stronger ones and of all interatomic distances into larger and smaller ones, we arrived at a picture which corresponds to the Frenkel model of a liquid. The high fluidity of fused NaCl can be attributed to the ease with which the melt forms fissures.

Crystals which form fissured liquids on melting cannot be overheated. Fissured liquids cannot be supercooled to the extent of forming glasses. The X-ray investigations of J. Zarzycki[4] revealed that we have to think of molten alkali halides as fissured liquids which correspond to Frenkel's model. Summarizing his extensive work on the atomic structures of fused fluorides and chlorides Zarzycki wrote:

"Analysis of the radial distribution curves deduced from the spectra by means of the spherical Fourier transform shows that for the alkali halides the short range order of the crystal is maintained in the molten state whereas the coordination numbers are much lower. This confirms the existence of 'holes' in these molten salts."

"With the aid of supplementary data it is shown that these 'holes' are actually 'fluctuating fissures' between ion clusters consisting on an average of one to two ionic shells surrounding a central ion."

3. *The Stewart Model*

G.W. Stewart[5] on the basis of X-ray studies suggested that molecular liquids may contain swarms of molecules which show some degree of temporary order. At the

time that Stewart developed his picture it was necessary to differentiate between ordered crystalline regions and non-crystalline groups of molecules which also show some order. Therefore, he coined the word "cybotaxis" and he called these swarms "cybotactic regions." At the present time the term "liquid structure" is used to indicate this condition of ordered molecules which have no relation to crystalline structure.

The characteristic feature of Stewart's model of a liquid is that it contains groups of molecules which are capable of becoming oriented when subjected to an outside force, i.e., stretching. Thus, we refer to Stewart's model as an "orientable" liquid.

G.W. Stewart[6] developed a model of liquids which reminds us of "crystalline liquids." He does not limit his model to molecular liquids as can be seen from the following remarks:

"The current discussions concerning order and disorder in solid alloys evidently have a definite bearing upon liquids. When two liquids form a homogeneous solution there is a single common liquid structure, but with an unknown degree of order. The phenomenon of solution, whether electrolytic or non-electrolytic, is concerned with forces that produce structure and that have a tendency to produce order corresponding to a superlattice."

The Stewart model can best be illustrated by the structure of amorphous sulfur which J. A. Prins[7] presented at a recent symposium on non-crystalline solids. According to Prins, the amorphous sulfur consists of a mixture of S_8 molecules and spirals of sulfur atoms. The simultaneous presence of several molecular species in itself would not make sulfur a Stewart liquid but the tendency of chain-like molecules to become oriented, in particular when stretched, justifies treating amorphous sulfur on the basis of the Stewart model. The chain molecules, even when they are ordered, do not represent crystals of sulfur nor do they nucleate crystallization because no crystalline modification of elemental sulfur is known which consists of chains. This is the main reason for our referring to amorphous sulfur and not to amorphous selenium which has been studied much more thoroughly with respect to its glassy properties. Amorphous selenium has a structure similar to that of sulfur, but unlike sulfur it can form a crystalline modification which consists of ordered chains. Using sulfur rather than selenium as an example we can better understand why the formation of ordered regions is not necessarily identical with the formation of crystals. A liquid may contain ordered regions which do not grow into crystals.

J. J. Trillat and H. Forestier[8], as well as K. H. Meyer and Y. Go[9], discovered that order could be introduced by stretching amorphous sulfur or selenium. This phenomenon provides a means for distinguishing between glasses which are supercooled "flawless liquids" corresponding to the Bernal model and those which are supercooled "complex heterogeneous liquids" corresponding to the Stewart model of an "orientable" liquid.

All efforts to find an orientation of chain-like macromolecules in fibers of silica, silicate, and borosilicate glasses have failed. Those anisotropies in the electron density distribution which have been discovered in stretched silicates refer to voids rather than matter (L. C. Hoffman and W. O. Statton[10]). This failure to induce orientation of matter agrees with our view that these glasses have structures which correspond closely to the Bernal model of a flawless liquid.

X-ray patterns revealed that fibers of vitreous B_2O_3 and of $NaPO_3$ did show orientation (B. K. Banerjee[11] and M. Goldstein and T. H. Davies[12]). The alkali phosphate glasses are the only oxide glasses which permit a direct chemical approach to their structures (chromatography), so that we have chemical evidence for the existence of chain-like polyphosphates in these glasses.

The presence of oriented groups in fibers of a boric oxide glass as suggested by their responses to X-rays has been confirmed recently by their magnetic anisotropy. B. K. Banerjee[13] made a very important contribution to our knowledge of the constitution of glasses when he measured the diamagnetism of glass fibers as a function of the direction. A B_2O_3 glass in spite of its chemical simplicity must have a complex and orientable structure resembling the Stewart model of a liquid.

The magnitude of the magnetic anisotropy is shown in Table I.

TABLE I

Boric oxide fibers	0.3111 to 0.4921 x 10^{-6}
Na borate fibers (10% Na_2O)	0.0307 to 0.0595 x 10^{-6}
Na borate fibers (31% Na_2O)	0.0091 to 0.0197 x 10^{-6}
Borosilicate fibers	0
Silica fibers	0

Vitreous silica is a supercooled flawless liquid which contains no chains, macromolecules, or swarms which can be oriented through stretching into a fiber but vitreous boric oxide contains orientable groups. The addition of alkali to boric oxide lowers the concentration of those polymers which can be oriented by drawing.

In order to cover all possible liquid structures we will use a scheme in which the three idealized models are arranged in the corners of an equilateral triangle such as is used for plotting a three-component system. (Fig. 1). Vitreous silica has a structure which is located close to the corner which represents the "flawless liquid" (Bernal model).

A boric oxide glass would have to be placed close to the corner which represents the "orientable liquid." The fused alkali halides have to be placed into the area of the triangle which is close to that corner which represents the "fissured liquid." We place into this area all those liquids which do not form glasses on cooling. Molten NaF and NaCl are very close to that corner but the nitrates of the alkalies occupy more remote positions

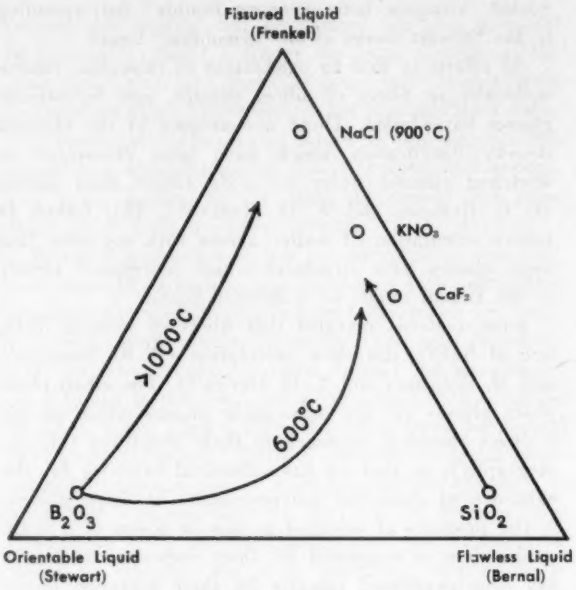

Fig. 1.—Schematic Representation of Liquid Structures

because complex alkali alkaline earth nitrates have been prepared in the glassy state so that nitrates in the molten state should resemble the crystal more than fused NaF or NaCl.

The observations of T. Baak* reveal that molten CaF_2 must have a structure which can be represented by a point perhaps midway between the corners of the flawless and the fissured liquid. Such a liquid contains holes but they do not lead to the fluctuating fissures which are characteristic for fused NaF.

In the third part of this series we discussed examples of chemically enforced glass formation, e.g., the effects which additions of SiO_2 and Al_2O_3 have on TeO_2, PbF_2 and Pb_2GeO_4 The pure substances form melts which contain fluctuating fissures and hence they crystallize. Adding Al^{3+} ions or Si^{4+} ions to such a melt decreases the probability of fissures forming. The non-polarizable Al^{3+} ion is not likely to be in a surface at this temperature because in such an incompletely screened condition it would strongly raise the energy of the system. The addition of Al_2O_3 changes the structures of these melts so that they correspond to points away from the corner which represents the fissured liquid so that glass formation becomes possible.

III. Some Properties of Glasses

Our shift of emphasis from the geometry as averaged over the total volume of the glass to the symmetry and the distribution of forces within the individual structural units provides a much needed approach to the understanding of those properties which depend upon forces. We do not expect that our approach to glass formation will be more useful than earlier approaches with respect to the understanding of density, refractive index and electronic interactions, e.g., light adsorption, solarization, and the response of glasses to high energy radiation.

However, the absorption of infrared or the Raman spectra of glasses are properties which reveal the forces which are acting between the atoms or ions. Hence our approach should be most helpful in the understanding of infrared spectra, and vice versa the infrared spectra of simple glasses should be a powerful tool for exploring their constitution with respect to the distribution of forces.

From those properties which can now be understood and which also are of practical importance to the glass technologist, we have selected the thermal expansivity and the change of the viscosity with temperature.

The thermal expansion of a glass does not involve any motion of atoms out of their equilibrium positions. Viscosity as a kinetic property is based on the rate of structural changes. Glass technologists are well aware of the fact that these two properties must be related in some way because low melting glasses, as a rule, have high thermal expansivities. It is unfortunate that in order to make a low-expansion glass, which has a high resistance to thermal shock, one has to use glass compositions which have high melting ranges. Among all glasses, vitreous silica has the lowest thermal expansivity but it is also the one which has the highest softening point.

1. *Thermal Expansivity*

In order to understand the reason why the volume of crystals and glasses normally increase with increasing temperature we have to analyze the response of these solids to the increasing thermal vibrations, and we have to discuss the several factors separately even if in reality they are closely interlinked. Due to the mutual polarization of the ions the volume of a crystal is frequently much smaller than one would expect from the sizes of the ions. Increasing temperature decreases the state of polarization over a time average. At high temperatures the ions interact with one another as if they were rigid spheres or points having excess charges. This change of the interaction causes many crystals which due to strong mutual polarization of their ions have a high density and a low symmetry at ordinary temperature to undergo one or more crystal modification changes if the temperature is raised. As a rule the high temperature forms of substances have higher symmetries and lower densities. It is not necessary, however, that the decrease of the mutual polarization of the ions changes the symmetry of a crystal, the volume expansion can occur independent of geometrical changes. The alkali halides of NaCl structure, for example, already have such a high symmetry that they do not undergo crystallographic changes on heating. An analysis of their expansivities[14] reveals those volume expansions which are the result of

* Discussed in Part III of this series. See The Glass Industry, *41*, (Dec., 1960).

the change of polarization. The expansivities of the alkali fluorides are nearly the same but those of the iodides show more variation and are greater. Within the series of iodides the thermal expansion decreases from LiI (strongest polarization) to RbI.

In addition to the change of the state of polarization the anharmonicity of the thermal vibrations causes the volume of solids to expand on heating. A lattice consisting of harmonic oscillators would not expand if the amplitudes increase with increasing temperatures because the average position of the atoms would remain the same regardless of the amplitudes of their oscillations. For a given thermal energy the amplitudes of vibration decrease with increasing strength of the binding forces. For a highly symmetrical structure in which the atoms are bonded together by strong forces the vibrations have only small amplitudes and in this case they resemble harmonic oscillators. Weak binding forces permit larger amplitudes of vibration and for large amplitudes the vibrations are less harmonic. This relation between the bond strength, the amplitude of vibration for a given thermal energy, and the anharmonicity led to the concept that solids with strong bonds have a low expansivity.

The anharmonicity of atomic vibrations increases with their increasing amplitude but the amplitudes of atomic vibrations should not be correlated with the average bond strength. With respect to the thermal expansivity of glasses we face exactly the same problem as with their viscosity. All conventional efforts to explain the widely different viscosities of vitreous B_2O_3 and SiO_2 failed.* Whether one approached the problem on the basis of the bond strength as derived from the heat of formation or on the basis of the Coulombic forces acting between ions the results were equally discouraging. There is no major difference between the strengths of the B-O and the Si-O bonds which could account for the drastic difference in viscosity. The linear thermal expansion of vitreous silica is 5×10^{-7} but that of vitreous B_2O_3 is 200×10^{-7}.

A comparison of the linear thermal expansions of three forms of SiO_2, in table II.

TABLE II

Silica glass	$= 5 \times 10^{-7}$
Low quartz	$= 120 \times 10^{-7}$
Low cristobalite	$= 200 \times 10^{-7}$

reveals that there can be no simple relation between the thermal expansivity and the average bond strength, not even for the different modifications of the same compound.

We attribute the lower melting point of quartz as compared with cristobalite which has a lower average bond strength to the difference which exists within the binding forces in different crystallographic directions. It is this asymmetry of forces which causes the thermal vibrations of the atoms in quartz to be less harmonic than in vitreous silica. Hence we attribute the low thermal expansivity of vitreous silica to the combination of three factors.

1. low polarizability of all ions and no major change of the state of polarization with temperature.

2. strong binding forces causing small amplitudes which favor harmonic vibrations.

3. high symmetry of the structural units which also favors harmonic vibrations (one Si-O force constant).

It is significant that a severely chilled glass can have a higher thermal expansivity than the same glass in annealed condition. This is most remarkable if one considers that a chilled glass has a lower density and a strong tendency to contract and that it will do so on heating as soon as the viscosity permits. We attribute the high thermal expansivity of chilled glasses primarily to the lesser symmetry of its structural units or the higher defect concentration and to a lesser extent to the weaker average binding forces (larger volume).

High symmetry of forces acting within the SiO_4 tetrahedra is a characteristic feature of vitreous silica. This symmetry is disturbed when alkali is introduced. The formation of non-bridging O^{2-} ions of high polarizability is equivalent to the formation of lattice defects because they are centers of an asymmetry of forces, they lead to a disproportionation of forces and Si-O distances. The work of H. H. Blau[15] on the thermal expansivity of sodium silicate glasses reveals the intricate changes of symmetry or the formation of super lattices which occur when the Na_2O concentration is changed.

H. H. Blau[15] developed an equation for the linear coefficient of expansions of silicate glasses which was based on the volume of that quantity of glass which contained one gram atom of oxygen. Using the silicon to oxygen ratio as the parameter he found that the thermal expansion revealed discontinuous structural changes.

Breaks were found, not only for those Si:O ratios which corresponded to shifts from one to two (0.286), two to three (0.333) and three to four bridging oxygens (0.400) per SiO_4 groups, but also for the ratio 0.444 at which one-half of all SiO_4 tetrahedra had one and the other half had no bridging O^{2-} ion. H. H. Blau concluded that there must be a regularity in the arrangement, otherwise it could not produce a break. The maximum stability of the glass structure seemed to be achieved if all non-bridging O^{2-} ions were equidistant, i.e., occupying positions which are as remote as possible from one another. He arrived at the conclusion that the non-bridging O^{2-} ions repel one another. We would express the same thought as follows: Maximum stability of the structure due to a maximum degree of screening of all silicons can be achieved if the distribution of non-bridging, highly polarizable O^{2-} ions is as even as possible throughout the glass structure.

E. Seddon and W. E. S. Turner[16] found transition points in the thermal expansivity of glasses at relatively low temperature (120° - 150°C). These volume changes

*Part I of this series. See THE GLASS INDUSTRY, 41, 429 (Aug.) and 487 (Sept., 1960).

of the rigid glasses are very likely related to changes of the symmetry within the distribution of the alkalies.

Our interpretation of the thermal expansivity makes this property a valuable tool for studying structural problems. M. Karkhanavala and F. A. Hummel[17] found that the low temperature thermal expansivity of a sodium strontium silicate glass did not change if SrO was gradually replaced by equivalent amounts of PbO. On the basis that the low temperature thermal expansivity reflects the symmetry of the structural units of the glass we conclude that Pb^{2+} and Sr^{2+} ions occupy equivalent positions in these glasses. We assume that the symmetry of their polyhedra, probably SrO_6 and PbO_6 octahedra is the same. This assumption explains the absence of visible absorption of the Pb^{2+} ions in glass as compared with a PbO crystal in which the Pb^{2+} ions occupy positions in an asymmetrical environment.

2. Viscosity

The viscosity of a liquid is related to the average bond strength only if the liquid has a structure which corresponds to the model of Bernal. In such a "flawless" liquid flow becomes possible when the thermal energy becomes sufficiently high so that it can overcome the average binding forces. As is to be expected, a crystal which melts to a "flawless" liquid can be overheated. Liquids of the "flawless" type have high viscosities slightly above the melting point of the substance. Their viscosities decrease strongly with increasing temperature because of the development of flaws and the resulting disproportionation of binding forces. However, in order to change the viscosity of most silicate glasses by a factor of 2, temperature changes of only a few degrees are required.

Glasses whose structures correspond to the model of Stewart, i.e., glasses which like B_2O_3 have an "orientable" structure, have viscosities which are very much lower than those anticipated on the basis of an average bond strength. The viscosity of an organic high polymer is not related to the average interatomic binding forces but is determined by the weaker forces acting between its molecules. This is an extreme example but it is obvious that there is no relation between the relatively low viscosity of vitreous B_2O_3 or that of P_2O_5 and the high B-O and P-O bond strength. These glasses resemble in their structure organic polymers. Their structural units may not have the same degree of permanency as the organic molecules but they are sufficiently permanent to be oriented by stretching. In alkali phosphate glasses the permanency of the macromolecules is sufficient so that they may be isolated and studied in aqueous solution.

Substances which on melting form liquids of the Frenkel type (fissured liquids) do not form glasses. These melts have very low viscosities even slightly above the melting point of the substances. Here, too, no relation exists between the viscosity of the melt and the average bond strength. The structure of these melts is controlled by fluctuating fissures which separate clusters of ions or molecules. In contrast to the "orientable" liquid such a melt is heterogeneous only in a dynamic sense because the clusters have lifetimes which are too short to arrange them in order. The low viscosity is determined by the weak forces acting between the clusters. The temperature dependence of their viscosities is considerably less than that of the "flawless" liquids. Viscosity changes by a factor of 2 require temperature changes of approximately 100°C for $PbCl_2$ and of 300-400°C for some metals.

All stable glasses have structures which must resemble either Bernal's model of the "flawless" liquid or Stewart's model of the "orientable" liquid. However, no matter where the point representing the structure is located in our scheme of liquid structures it will move closer to that of Frenkel's model of a fissured liquid if the temperature is raised.

It is this structural difference which sets apart glass-forming liquids from normal liquids. For many simple liquids viscous flow can be described as a process which has a constant activation energy so that the viscosity changes with temperature according to a simple exponential law. For glass-forming liquids no formula has yet been derived on a theoretical basis which can describe the change of viscosity with temperature. Heating a glass produces structural changes which become noticeable above T_g. Regardless of the composition of the glass and the absolute value of T_g, at this temperature the structure changes in the direction toward the "fissured" liquid. All solids develop defects on heating and all defects disproportionate the binding forces into stronger and weaker forces. The weak forces or the fluctuating fissures enable a system to flow at a temperature at which the thermal energy is not sufficient to overcome the average bond strength. For this reason the viscosity of glasses decreases with increasing temperature much more than one would expect for a rate process controlled by an energy barrier even if we take into consideration that the volume increase on heating must weaken the average binding forces and may lower the energy barrier. The effect which the increase of the number of defects beginning at T_g has upon the viscosity cannot be calculated but it can be bypassed to a certain extent by not plotting the log of the viscosity against $1/T$ as is usually done but against T_g/T as has been suggested by W. Oldekop[18]. Using this plot the curves of glasses which have widely different compositions and transformation regions fall practically together.

Chilling a glass affects its viscosity much more than its thermal expansion. Chilling not only freezes in a higher concentration of defects but it also increases the volume of the glass and with it its polarizability. In the transformation region of a glass the number of defects changes at a measurable rate and, consequently, the

(*Continued on page* 168)

HOWARD R. LILLIE, manager of the research and development division of Corning Glass Works, was among the 73 killed in the crash of the Sabena Airlines Boeing 707 jet near Brussels Airport early Wednesday morning, February 15.

President of the International Commission on Glass, he was traveling to Brussels for a meeting of the Commission's executive committee to issue a report on the International Glass Congress which will be held in Washington, D. C., in July, 1962.

His daughter, Alice, whom he planned to visit, is spending the winter term in Italy as part of the overseas study program at Lake Erie College, Painesville, O., where she is in her junior year.

As staff research manager since 1958, Mr. Lillie was responsible for coordinating all technical activities of Corning's research and development division. He helped develop many of the company's special glasses, having worked principally on the physical properties of glass, with emphasis on viscosity, as well as color, expansion and refractive index.

Howard R. Lillie

Mr. Lillie was internationally known for pioneering research in glass viscosity and for the accurate methods of measuring glass viscosity (he was a founder of the Society of Rheology). Procedures which he developed for controls in the manufacture of glass are in use throughout the world.

He held six patents jointly with Dr. Jesse T. Littleton, honorary vice-president of Corning Glass Works, and Dr. William W. Shaver, manager of the company's fundamental physical research department.

He was a Fellow of the American Ceramic Society and had been president of the organization in 1951. He was also a Fellow of the Society of Glass Technology in England and was in the second year of a three-year term as president of the International Commission on Glass.

He joined Corning in 1927 as a research physicist, became manager of fundamental research in 1954, and manager of fundamental physical research in 1955.

Survivors are his daughter and his wife, the former Jennie E. Hammond.

"The glass industry—indeed the entire field of science—has lost one of its great leaders in the death of Mr. Howard R. Lillie.

"Mr. Lillie was internationally famous for pioneering research in the field of glass viscosity and the accurate methods of measuring glass viscosity. The procedures he developed for controls in the manufacture of glass are in worldwide use.

"Throughout the years, Mr. Lillie took a great interest in furthering the professional organizations in the glass and ceramic field. Over a period of years, he served on many committees of the American Ceramic Society. This culminated in his presidency of the Society in 1951.

"Since that time he continued to be active in an advisory capacity to officers of the Society and has taken an active interest in the International Commission on Glass.

"The high esteem in which Mr. Lillie was held throughout the world was demonstrated by his election as president of this Commission.

"We of Corning Glass Works, and particularly the Research and Development Division, feel a tremendous professional and personal loss."

—DR. WILLIAM H. ARMISTEAD,
vice-president and director,
Research Development Division

"The tragic death of Mr. Howard R. Lillie has brought a personal loss to all of us who were associated with him. During my years as director of research I worked closely with Mr. Lillie.

"Mr. Lillie's contributions to the glass industry have been recognized throughout the world. He held an international reputation as an authority on the measurement of glass viscosity.

"His death creates a real vacancy at Corning Glass Works. The entire glass industry has lost one of its outstanding leaders."

—DR. EUGENE C. SULLIVAN,
honorary chairman of the board,
Corning Glass Works

The Glass Industry 1960

A REVIEW (*concluded*)

by H. E. Simpson,

State University of New York College of Ceramics, Alfred University, Alfred, New York

III. TECHNICAL GLASS

Many significant advances were made in glass fo technical and scientific uses during 1960.

Mirror Blanks

Corning Glass Works is producing a 62-inch diamete mirror blank and a 35-inch disk, both of fused silica, for a telescope to be constructed by the U.S. Naval Observatory near Flagstaff, Arizona. The 62-inch telescope, designed to provide previously unobtainable information on stars up to 100 light years or 600 trillion miles from the sun, will also enable astronomers to observe deep space probes and distant artificial satellites.

Fused silica was selected for the mirrors because the material is virtually unaffected by temperature variations, having a thermal expansion rate one-fourth that of the borosilicated glass used in many telescopes.

Infrared Transmitting Glasses

Detailed information has been released on three infrared transmitting glasses, also produced by Corning. Designated as Code 0160; Vycor Brand Glass 7905, a special 96 per cent silica glass; and Corning Brand White Crystal IR Glass 9752, the last two are being used in IR-guided missiles. The 9752 glass is a new composition with improved infrared transmission and is offered for missile application and for use in optcal nstruments.

High-Speed Printing Bulb

A cathode ray bulb with 35,000 separate wire conductors embedded in a face plate 3" by ¼" in size has been developed for high-speed electronic printing. The

new process is capable of printing 20,000 characters a second. It also can be used to transmit by microwave or wire systems facsimiles of graphic and printed materials—documents, records, maps, and mail. The bulb design was a cooperative effort by Corning and Sylvania Electric Products, Inc., the latter processing the finished tube.

Each conductor in the rectangular matrix of the face plate is 0.001" in diameter—half the thickness of a strand of human hair. Nominal space between conductors is 0.003". These conductors serve to transfer an electrostatic charge from an electron beam to moving paper. The information may be obtained from a computer or from magnetic tape. The machine, Videograph, prints information as fast as it can be fed to the equipment.

High-Temperature Glass for Mercury Capsule

Viewports or windows for the National Aeronautics and Space Administration's Mercury space capsules will be made of polished, high temperature glass, four panes thick. They are designed to remain intact through the heat and shock of re-entry as well as to remain watertight in an ocean landing. The ports will enable the pilot to determine the attitude of the vehicle and to take astronomical photographs. The glass panes must withstand the same environmental stresses as the capsule's triple-layered metal walls.

The windows will include two outer panels of a 96 per cent silica glass and two inner panes of heat resistant aluminosilicate glass. Air spaces between the panes will retard heat transfer to the inside of the space capsule. The two innermost panels will be tempered for greater strength.

The outer pane of glass will be curved to the outside contour of the capsule. It is a trapezoid 21 inches in height, with width ranging from 7½ inches at the top to 11 inches at the bottom. Inner panes are flat and reduced in size, with the innermost panel being approximately 13 inches high.

Fused Silica Mirror for Balloon Telescope

The largest fused silica mirror ever made will serve as the primary reflective piece in a 36-inch telescope to be carried aloft by an unmanned balloon for outer-space photography. The mirror blanks consist of two fused silica plates separated by walls or tubes of the same high purity glass. The ribs (to maintain rigidity) are permanently sealed to each plate under intense heat. With this type of construction, and dependent on design, mirror weight can be reduced to half that of a solid disk with equal surface area.

The goal of the project is to obtain photographs of planets and other celestial bodies at altitudes above the turbulence of the earth's atmosphere. It is planned to send the balloon to an altitude of over 80,000 feet.

With the larger telescope, it is expected that new photographs will provide information on the atmosphere of Jupiter and Venus, permit analysis of the division of Saturn's rings, and provide a means of measuring the diameter of Pluto. The project also may shed further light on the Great Nebula in Orion where new stars apparently are forming continually in dense interstellar clouds.

Low-Cost Pillows and Balls

Tiny pillows and balls of glass are being produced as a low-cost material for filler, packing, filtering, and tumbling applications. The pillows, including both solid and hollow pieces, are being made in lengths up to ½". The balls are manufactured up to diameters of ½".

The hollow pillows provide a low density filler material for such applications as packing in aircraft wings where the glass gives both structural support and buoyancy. They also can be used as a filler material in the casting of larger plastic pieces.

The solid pillows are being used in chemical processing as fillers in refractionating columns and in filter beds. Their tumbling action provides the necessary agitation in electroplating operations.

In commercial application, the ball-shaped pieces are used in the anti-lint filter of an automatic washing machine. The balls pick up the lint which is then backflushed, thus preventing clogging and stoppages.

Mercury Capsule Antenna Shields

The condition and position of the first American in space will be flashed to Earth through thin, cylindrical shields of glass. The shields, transparent to radio signals, will protect transmitting and receiving antennas on Project Mercury capsules, especially during re-entry heat and shock.

Corning's 96 per cent silica glass was used for the shields because of its breakage resistance and stable electrical characteristics under sudden and extreme temperature changes. The shields are formed by grinding blank pieces of glass to required thickness, sagging them under heat to the precise curve needed, cutting them to size, then bathing them in acid to impart high strength.

Radio signals streaming back to Earth through the antenna shields will carry critical information about the astronaut's heart rate, blood pressure, and body temperature. They also will keep track of the capsule's acceleration, assist in prediction of possible landing points, and monitor such capsule functions as oxygen pressurization. Voice communications also will be transmitted and received by capsule antennas through the shields.

Glass With Low Radioactivity

A new kind of glass has been developed for the Atomic Energy Commission to help scientists detect and identify extremely tiny amounts of radiation. The glass will be used to make bulbs, headers and other components of photomultiplier tubes, a vital part of radiation-measuring equipment.

An immediate use of the equipment is the fast and accurate measurement of beta and gamma radiation in human beings, the atmosphere, foods, clothing, shelters, and other objects, whether the radiation comes from fallout or natural sources.

According to latest information the new glass has a radioactivity of less than 10 counts per minute per kilogram. Most glasses in present use have a count of more than 175. It has been noted that 96 per cent silica glass has a count of about 50.

The new glass is easily formed and seals well to Dumet, Sylvania No. 4 and similar alloys. The equipment containing the glass can also be used for extremely precise measurements needed for dating of materials or other research problems.

Glass Helps New Machine Detect Homemade Bombs in Suitcases

A new device, actually a small fluoroscope, is being manufactured by Daly Industrial X-Ray System of Los Angeles for detecting bombs and other dangerous objects. Its "windows" are pieces of radiation shielding glass about the size of a standard building brick.

Set up at an airport luggage scale, it can quickly scan the inside of a suitcase.

The radiation shielding windows permit the machine to do its job properly without injury to airport personnel because the glass screens out harmful radiation; it also allows direct viewing—rather than indirect viewing through a series of mirrors.

Glass for Aircraft Dials

Mass-produced photosensitive glass that can be precision patterned by chemical machining is now being used for aircraft dials. The dial blanks, hold up under temperatures that deform other dial materials. Through the use of a photosensitive process, pieces can be accurately patterned at low cost by simple art work. The "Fotoform" dial pieces are delivered to the aircraft dial manufacturer as chemically cut and patterned blanks. Numbers and graduations are then applied.

IV. ELECTRONICS

The remarkable growth of the electronics industry is attributable to the ever-widening versatility of electronic techniques. The extensive range of tasks electronics can perform makes possible its application in every basic industrial and commercial activity. It has become the common denominator of weapons for defense. It continues to be an important increment of the consumer market, bringing more entertainment and labor-saving devices into the American home.

Each market for electronic products—consumer, industrial, military, and replacement components—enjoyed a greater annual volume during 1959 than in any preceding year. Especially significant was the recovery of the consumer market from its 1958 decline. Stimulated by rising economic activity, higher consumer incomes, greater automobile sales, and new product promotions, consumer electronic sales at the factory level totaled $2 billion, a $400-million increase over the previous year. This trend continued during 1960.

Rising missile expenditures and the greater electronic content of military equipment are prime factors behind the steady expansion of the military market. Electronic sales to this sector during 1959 are estimated at $4.7 billion, approximately 7 per cent higher than in 1958.

Of major significance during the 1950 decade was the change in the relative importance of market areas. Continued emphasis on production for defense, as well as expanding requirements of the industrial market during this period, caused manufacturers to analyze closely current and future defense needs and to view more carefully long-term variations in capital investments. Sales of military and industrial products since 1950 have continued upward to reach $6.3-billion during 1959, 68 per cent of total factory billing. During 1950, manufacturers' sales of military and industrial items were only $850-million or 33 per cent of the total. It is anticipated that manufacturers' total factory sales for all categories will exceed $10-billion in 1960, an increase of 8.7 per cent over the 1959 total of $9.2-billion. While it is difficult to forecast the future, it seems likely that this present rate of increase will continue.

Civilian programs initiated by the Federal Government are creating additional markets for electronics. Federal Aviation Agency plans to modernize air traffic control centers, for example, will affect broad product areas, including computers, communications, and navigational aids. Perhaps of greater long-range importance are Government space programs which are requiring increasing electronics content in the design and fabrication of space vehicle payloads; data acquisition, reduction and transmission; and guidance and control of booster rockets.

Television

During the past decade the number of television sets in use increased five fold to reach 53.3 million by the end of 1959. Some 89 per cent of 52 million U. S. homes now contain TV sets compared to the 86 per cent of 51 million homes at the end of 1958 and 83 per cent of 50 million homes at the end of 1957.

Production of monochrome TV during 1959 totaled 6.3 million units, 29 per cent higher than 1958's ten-year low of 4.9 million, and 19 per cent less than 1955's all time high of 7.8 million units. Portable and table models enjoyed approixmately the same share of total TV production as the previous year, rising only slightly from 55 per cent (2.7 million units) to 57 per cent (3.6 million units).

Production of TV sets for the period January through

July 1960 amounted to 3,231,898 units, while retail sales totalled 3,050,385 units.

TABLE III

TELEVISION PRODUCTION

Year	Table—Portable	Console	Phono—Comb.	Total	Value (000 omitted)
1947.....	116,315	37,039	25,217	178,571	50,000
1948.....	646,509	179,181	149,310	975,000	230,000
1949.....	1,792,691	989,220	218,089	3,000,000	580,000
1950.....	2,941,560	3,820,060	702,180	7,463,800	1,350,000
1951.....	2,275,901	2,774,859	334,038	5,384,798	956,986
1952.....	2,837,507	3,038,895	219,878	6,096,280	1,049,000
1953.....	3,224,724	3,755,340	235,763	7,215,827	1,230,298
1954.....	4,249,339	3,011,536	85,840	7,346,715	1,028,540
1955.....	4,439,676	3,199,796	117,049	7,756,521	1,071,020
1956.....	4,753,787	2,556,845	75,397	7,387,029	938,596
1957.....	3,845,807	2,433,449	120,089	6,399,345	832,747
1958.....	2,716,876	2,068,627	134,925	4,920,428	667,899
1959.....	3,612,638	2,566,950	169,792	6,349,380	896,405
1960.....	.....	.....	.....	5,700,000*	800,000*

* Estimated by Electronic Industries Association.

Radios

Radio production during 1959 climbed 33 per cent over 1958 to total 15.6 million units, its highest point in 12 years, Portable and clock radios established production records at 4.1 million units and 2.8 million units respectively. Auto radio production rose 50 per cent over the previous year to total 5.6 million units.

Continuing the miniaturization trend, 95 per cent of all portables produced were transistorized, a significant increase over the 81 per cent of 3.4 million units during 1958 and the 50 per cent of 3.3 million units during 1957.

Production of home radios for the period January through July 1960 amounted to 5,763,778 units, while retail sales totalled 4,451,721 units. Production figures for auto radios for the same period were listed as 3,651,101 units.

Industrial Products

While electronic techniques are being incorporated in a greater variety of consumer products, it is in the industrial area that the enormous breadth and versatility of electronic methods are most clearly illustrated. Automatic controls, dielectric heating equipment, infrared, ultrasonics and radiation detection devices are utilized in manufacturing processes. Closed-circuit television is used for monitoring production, for observing traffic at railway and trucking terminals, and for multi-city audiovisual communications. Electronic diagnostic and therapeutic equipment is increasingly employed by medical practitioners and researchers. Nuclear electronics, an outgrowth of the atomic age, is another growing segment within the industrial category.

From 1954 through 1957, estimated yearly sales of electronic equipment for industrial, commercial and non-military Government purposes increased at an accelerating rate from $650-million to $1.3-billion. Although the 1958 recession year adversely affected the annual rate of increase, sales continued to expand during 1959 to establish a record of about $1.6-billion.

Expanding applications for computers, data processing, and industrial controls are the principal reasons for industrial electronics growth. Six years ago, they accounted for slightly over $100 million in annual sales, or about one-sixth of the total estimated "Industrial Products" market. Today, they are selling at an annual rate of well over $500-million to comprise one-third of the industrial market.

TABLE IV

FACTORY SALES OF INDUSTRIAL PRODUCTS

(In Millions of Dollars)

Equipment Type	1956	1957	1958	1959
Computing, Data Processing and Industrial Control Equipment	$ 240.0	$ 415.0	$ 450.0	$ 525.0
Testing and Measuring Equipment	170.0	210.0	220.0	245.0
Landmobile, Microwave, and Broadcasting Equipment	120.0	150.0	155.0	175.0
Other Industrial Products	420.0	525.0	555.0	655.0
TOTAL	$950.0	$1,300.0	$1,380.0	$1,600.0

Testing and Measuring Equipment

The electronic test-equipment industry, which is an outgrowth of the electrical test instrument field, has evolved concurrently with developments in radio broadcasting, radar, television, and subsequent electronic innovations. Since the inception of the vacuum tube, the capabilities of test instruments have increased steadily with many new instrument types being introduced. Audio oscillators, tube testers, and specialized wave-form analyzers have been developed to permit a wide range of testing. Cathode-ray oscilloscopes have become extremely common and comprise a significant portion of today's annual sales volume. More recently, applications of semiconductors have necessitated the development of instruments to test transistors, rectifiers, and other solid-state devices.

Nuclear-Electronic Apparatus

Expanding nuclear-electronic instrument sales for purposes of radiation detection, measuring, and control are attributable to greater nuclear reactor construction and radioisotope utilization by manufacturers, physicians, and scientists.

Electronic detection and measuring devices used in conjunction with radioactive isotopes are increasing efficiency and reducing costs in manufacturing processes. Radiation gauges ensure uniform thickness and density of plastic, rubber, glass, paper, aluminum, and other materials. Isotopes are also used as radiation sources in tracing operations and have been successfully applied

in the petroleum, textile, and other major industries.

Military Products

Military purchases of electronic products during the calendar year 1959 are conservatively estimated by EIA at $4.7-billion, more than nine times the $500 million in military electronic purchases during 1950. Today, the military market for electronic products absorbs about 51 per cent of total U. S. electronic sales. In 1950, military purchases were less than 20 per cent of total sales.

The 1961 defense budget reflects a trend toward increased spending for research, development, test and evaluation (RDT&E) of new and improved weapons systems and equipment. Although the $13.6-billion budgeted for weapons systems procurement represents a decline of $808-million since 1959, this amount is more than offset by funds for RDT&E, which increased from $2.6-billion to $3.9-billion.

Missile Electronics

The rapid increase of electronic missile sales is a prime factor behind the remarkable growth of the electronic industry during recent years. In fiscal 1955, somewhat more than $300 million of $718 billion in missile expenditures was absorbed by electronics. Of the $3.5 billion spent for missile production in fiscal 1959, approximately $1.6 billion consisted of electronics.

Electronic equipment is used in missile systems for guidance, control, and information transmission. Compact electronic gear within a missile, for example, translate and amplify signals from ground-control stations to operate missile control surfaces and guide it on a given path. Ground-based guidance systems serve the remotely controlled Minuteman, Atlas, and Titan missiles. Other supporting systems, including ground communications and testing equipment, fulfill vital functions in missile operations.

The 1961 budget reflects continued emphasis on missiles of all types in national defense.

Electron Tubes

Electron tubes—receiving, TV picture, transmitting, and special purpose tubes—attained a 1959 factory sales total of $775-million, up 13 per cent from the $688-million in factory sales during 1958.

Receiving tubes, which are the common types found in radio and television receivers, accounted for $369-million or nearly one-half of the value of all tubes sold during 1959. A total of 433 million units were sold compared to 397 million units during the previous year. Sales to the initial equipment market registered the largest percentage gain by increasing 19 per cent over 1958 to reach 228 million units. Export sales declined, however, from 25 million units to 20 million units. Factory sales of receiving tubes for the period January through July 1960 amounted to 229,373,000 units ($195,718,000).

Television picture tubes, which evolved from the industrial type cathode ray tube, are a special kind of receiving tube in which a beam of electrons from the cathode falls on a screen inside a tube. Manufacturers' sales of picture tubes reached 9.5 million during 1959, more than a million units higher than 1958. The dollar value of 1959 sales totalled $184-million, up from the $163-million during 1958 and approximately equal to the $183-million during 1957. Factory sales of TV picture tubes for the period January through July 1960 amounted to 5,136,581 units, a value of $102,497,735.

TABLE V

MANUFACTURERS' SALES OF RECEIVING TUBES

BY END USE

(000 omitted)

Year	Initial	Renewal	Export	Government*	Total	Valu
1950	301,483	69,325	10,768	1,385	382,961	250,0 0
1951	247,855	94,597	24,438	8,754	375,644	261,0 0
1952	241,406	83,843	13,935	29,335	368,519	259,1 6
1953	293,601	112,785	20,614	10,091	437,091	303,6 5
1954	246,729	115,358	15,922	7,080	385,089	275,9 9
1955	288,810	150,718	24,442	15,832	479,802	358,1 0
1956	262,898	166,558	25,397	9,333	464,186	374,1 6
1957	240,708	184,493	23,378	7,845	456,424	384,4 2
1958	191,832	167,805	24,597	13,132	397,366	341,9 9
1959	227,669	170,729	19,969	14,569	432,936	368,8 2

* Includes only direct sales after 1954.

Factory sales of power and special purpose tubes reached 6.9 million units during 1959 at $222 million, compared with 5.4 million units at $183 million during 1958. Power tubes—klystrons, magnetrons, thyratrons, etc.—are used in the transmission of radio and TV signals, in radar and other military devices, and in certain industrial equipment. Included among special purpose tubes are Geiger-Muller and other radiation detection tubes which are used in nuclear activities; photo tubes, which are utilized in light meters, lighting systems, and television; and X-ray tubes. Factory sales of transmitting and special purpose tubes for the period January through June 1960 amounted to 3,454,047 units, a value of $117,476,482.

Among interesting tube innovations during 1959 was the new thimble-sized "Nuvistor." Already produced in sampling quantities, these tubes are expected to lead to important developments in televisions, other communications receivers, and computers.

A new kind of picture tube was also developed during 1959. In contrast to a single-stream beam employed in conventional tubes, the new device, called the "Multiton," splits the electron stream into three beams, and refocuses the beams into a single stream. This method is expected to provide a clearer picture, especially in areas where signals are weak.

Data presented in the tables of the electronic section were taken, for the most part, from "1960 Fact Book," prepared by the Electronics Industries Association.

TABLE VI

MANUFACTURERS' SALES OF PICTURE TUBES BY SCREEN SIZE*

	1948	1949	1950	1951	1952	1953
15" and Under	1,145,583	3,316,676	2,365,380	437,148	289,149	155,580
16" thru 18"	9,123	179,682	5,356,102	3,586,976	3,004,786	3,065,102
19" thru 21"	—	—	211,940	973,233	4,296,735	6,105,068
22" thru 25"	—	—	—	120,739	30,409	275,504
26" and Over	—	—	—	—	—	119,964
Projection	154,470	16,601	23,645	17,703	6,983	6,120
	1954	1955	1956	1957	1958	1959
15" and Under	235,954	412,226	1,595,940	517,598	289,149	155,530
16" thru 18"	2,086,077	1,805,081	1,908,933	2,231,449	2,063,900	2,932,196
19" thru 21"	7,223,259	7,674,175	6,713,446	6,414,945	5,511,011	5,643,710
22" thru 25"	318,665	948,104	741,512	534,570	370,982	778,780
26" and Over	46,925	34,648	27,190	22,446	17,438	12,280
Projection	2,624	**	**	**	**	—

* Made from new glass
** Included with 15" and under

FUTURE TRENDS

The world is entering an era of great change, in which glass will play an important part.

Plans, financed by Pillington Brothers, Ltd., have been drawn for a community of 30,000, in which every family unit will have a parking place upstairs and motorists and pedestrians will be totally segregated. The planning is designed to show what can be done with unfettered community planning, and plenty of glass.

The project, has been named Motopia because it purports to show how life can be livable, even where the automobile is king.

The planners conceived Motopia as one of Britain's "new towns," which are residential communities built for the purpose of "decanting" London or other overcrowded cities. Their hypothetical site was a level green area adjoining the Staines reservoirs, 17 miles west of London.

The rows of apartments criss-crossing the area are 5 stories high, with the parking level on the fifth and the roadway on the roof. The open green spaces within the rows are 800 by 1,200 feet. Smaller open-air patios are formed by circular buildings at each intersection.

Within the circles are the neighborhood pubs and shops. Shopping and other community activities are conducted at an integrated center along one side of the Motopia. Motorists can drive to the center and park on its roof. Pedestrians are given a wider choice and can walk, board one of the "water-buses" serving the canals along alternate rows, or step on a moving sidewalk going directly to the shopping area.

Expanding Markets

New and expanding markets will evolve from the applications of space-age technology to electronics production for commerce, industry, and the consumer. The impact will be felt more distinctly in commercial and public-service activities. For example, electronic devices placed in orbit will forecast the weather; aid ships in navigation; improve world-wide communications by serving as relay stations for signals; and permit long range point-to-point communications at low levels, thus conserving the crowded radio frequency spectrum. Satellites containing electronics will patrol for ice-bergs, warn of forest fires, map the earth's surface and conduct geological surveys. For the consumer, new heating and air-conditioning techniques will result from the successful control of the environment within a space capsule.

The space era has already induced a strong trend toward "smallness" in electronics as researchers seek a new technology for the design and fabrication of physically minute systems. Research programs in hundreds of firms are highly oriented by concepts of microminaturization based upon functional circuits rather than by complex re-design of components and component assembly techniques.

Electronic equipments which have enjoyed significant size reductions through printed circuitry and transistorization are experiencing further diminution as a result of micro-module research and development. These micro-modules are units in which tiny ceramic wafers containing semiconducting and insulating materials are combined to perform the electronic functions of basic components such as resistors, capacitors, and transistors. More than $7 million has been spent in the micro-module research program by the Army Signal Corps since its inception in April 1957. Already used to some degree by the military, micro-modules will save critical space and weight in portable ground communications, helmet radios, guided missiles, and satellites.

Further in the future are the revolutionizing prospects of molecular electronics. Presently in the applied research stage, this field involves the molecular rearrangement of materials in such a way that single blocks of matter perform functions of complete circuits. As a result of this work, entirely different concepts are in prospect for the construction of missiles, space vehicles, and a variety of conventional equipment. (*The End*)

Bibliography on Glass Structure*

PART IX

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Apparatus: Coaxial-cylinder. Outer cylinder of graphite, inner-tungsten; Furnace lined with carbon SiO_2 + 0.01% Al_2O_3

1720°	2.94×10^6
1800	5.74×10^5
1880	1.47×10^5
1940	5.60×10^4
2000	2.83×10^4

Molten SiO_2 presumably contains aggregates of some 100 mols. The size of the aggregates is reduced by heating and by addition of metal oxides.

255. G. Champetier

"Viscosity and Structure," Peintures, pigments, vernis 17, 662-6 (1942); Chem. Abs. (18) 40, 5319 (1946).

A discussion of the fundamental concepts of viscosity in relation to solids, solutions, emulsions, and suspensions, with particular reference to macromol. substances and the application of Staudinger's rule.

256. A. Dietzel

"Interpretation of Typical Expansion Effects of Silica Glass and Special Glasses," Naturwissenshaften, 31, 22-3 (1943).

Quartz glass has a coefficient of expansion with a maximum of about 6 to 6.7×10^{-7} between 200 and 400° (250°). Glasses made from SiO_2 and TiO_2 have even lower coefficients, down to 0.1×10^{-7}. Glass made by melting SiO_2 with Al_2O_3 has practically the same coefficient as pure SiO_2. The SiO_2 glass is a mixed ion and atom lattice (Brill. et al, C. A. *34*, 13). The effect of introduction of Ti in an ionic lattice would be to loosen the ions, hence increase the expansion coefficient; the effect on an atom lattice would be that of strengthening the lattice. Evidently Ti^{++++} has the latter effect; with Al^{+++} the two effects compensate. The decreased coefficient at high temperature with straight SiO_2 is explained by an increasing tendency to ion-lattice formation at higher temperature.

257. N. A. Yajnik, Ram Chand and D. C. Jain

"Magnetic Evidence Regarding the Valency of Colorant Ions in Glass. II," J. Indian Chem. Soc., 20, 169-70 (1943); Chem. Abs. 38, 903 (1944); Cer. Abs. 32, 103.

Valency and the state of Fe ions in glasses prepared by using borax and microcosmic salt were determined with the aid of chemical analysis and magnetic susceptibility measurements. With borax glasses, Fe imparted a yellow color under oxidizing conditions and green under reducing conditions, when cold. In microcosmic glasses, yellowish brown and greenish brown colors were obtained under corresponding conditions. Observed and calculated values for magnetic susceptibility are given.

258. Yves Godron

"The Softening Point of Glass," Bull. Inst. Verre, 4, 16-2[illegible] (1946); C. A. 41, 841h (1947).

A review comprising a discussion of the different definitions and of the dilatometric and Littleton test methods (C. A. *35*, 1587_7). Godron mentions the colloidal theory of glass by Bary (C. A. *19*, 2114 the thermal theory of the Anglo-Saxon school, the theory of ion rotation by Tamman and his own ideas on the alpha and beta phases in glass. None account for the physical reality of the softening point.

259. Joseph Lukesh

"Silicate Glass Structure, Species Density Analysis of Science," 104, 199-201 (1946); C. A. 41, 328i (1947).

The species density is the product of total density by the weight percent of each (at. or mol.) species. When the density of Na silicate glasses is plotted against the Si:O ratio, there are breaks at 0.500 (quartz, tridymite, cristobalite), 0.433, 0.400 (mica), 0.364 (amphibole), and 0.333 (puroxene). When the species densities are similarly plotted, the only break for the Si + O framework occurs at 0.433, whereas the plot for Na shows all the breaks of the total density curve. The break at 0.433 is related to saturation of the cristobalite-like structure of the silicate glass with Na atoms. Above this ratio, Na atoms are accommodated by voids. Below this ratio the voids in the framework are full, and the whole structure expands as additional Na atoms are added. The curves obtained are essentially phase diagrams: the composition regions are called structure phases. The framework of Na silicate glasses has two structure-phases, above and below the ratio 0.433. The latter is subdivided into subphases, which are characterized by different packing laws of the Na atoms. In the K silicate system the framework has only one structure phase with some subphases. In 3-component systems such as Na K silicate, the metal:O ratio is used. Few of experimental data are required for the construction

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of species-density diagrams. When the Al takes the Si position at the center of the O tetrahedron, the structure depends on the (Al + Si) : Si ratio, rather than Si:O.

260. J. M. Stevels

"The Physical Properties of Glasses. V. A Peculiar Phenomenon in the Vitreous System Na_2O-B_2O_3," J. Soc. Glass Technol. 30, 302-5 (1946).

The d-concentration curve of Na borate glasses determined and the S-shaped curve found is discussed. At a concentration of 4% Na_2O a widening of the O network is found which is not connected essentially with the sudden increase of the electrical conductivity at this composition.

261. J. M. Stevels

"The Physical Properties of Glasses—VI," J. Soc. Glass Tech. 30, 302-5 (1946).

The relationship between the volume and the number of glass-forming ions in silicate glasses. Ibid. 306-9. It is shown that, at least in silicate glasses, there is no perceptible difference between the volumes of a bridging and non-bridging O ion. The volume of the interstices in the O network is proportional to R (R being the ratio of the nO = of O ions present to the number of glass-forming ions present) as deduced from a simple model of the glass structure. By using these two results it is possible to calculate as a function of R the volume of a block of glass containing one gram atom of O ions. The values of V obtained in this way are identical, within the limits of error involved with those derived from the formula $V = V_o/11\text{-}R_x$), obtained previously.

262. J. M. Stevels

"The Physical Properties of Glasses—VII," J. Soc. Glass Tech. 30, 302-5 (1946).

The molecular refraction of glasses. Ibid. 310-17. It is shown that the mol refraction of abnormal glasses can be calculated in an additive way, with the aid of atom (ionic) refractions, provided that distinction is made between bridging and non-bridging O ions. This additivity is not expected for the normal glasses. These expectations are realized for a large number of pure silicate glasses containing Na^+, K^+, and Ca^{++} ions only. The deviations between experimental and calculated mol refractions for the abnormal glasses are less than 0.3%. Glasses containing isolated O tetrahedra were not examined.

263. J. M. Stevels

"Vitreous State," Philips Tech. Rev., 8 (8) 231-37 (1946); Cer. Abs. 30, 130.

The vitreous state of matter is the solid state of aggregation which occurs when a liquid solidifies without crystallizing. Stevels discusses the factors that exert influence on the tendency of a substance to solidify in the vitreous form. The most important cause of the formation of glass is an association of the atoms of the liquid, which leads to larger and larger complexes upon decreasing temperature of the liquid. Under certain circumstances these complexes have practically no tendency to pass over into a crystalline structure. The mass then solidifies in such a way that the arrangement of the atoms, considered over short distances, exhibits much similarity with that in a crystal, while over distances of more than a few atoms there is no regular arrangement. In the case of the glass-forming oxides, a detailed study is made of the characteristics of their structure responsible for their tendency to form glasses, following in the main the conceptions of Zachareisen. A discussion is given of the inorganic glasses formed by fusing together different oxides. A glass can best be composed of a suitable acid oxide as glass former and basic oxides that lower the temperature of fusion. 7 figures, 1 reference.

264. S. D. Chetverikov

"Relation Between the Optical Properties of Silicates and Their Structure and Composition," Vestnik Moskov. Univ. 1947, No. 6, 47-57; cf. Wooster, C. A. 26, 1841; C. A. 44 (2), 400.

Graphic methods in triangular or tetrahedral projections are used for the study of the relations between the n and the crystal structure of silicate minerals. There are, however, no direct general relations between the chemical composition and the atom or mol refractions (calculated from the Lorentz-Lorenz formula), and only approximating methods can be used. The volume V_o of one O ion in the elementary cell is empirically related to the average n of crystal phases having a similar chemical composition. In addition there is a particular effect of the position of the Al ions in the structure in so far as the octahedral coordination of Al increases n. In comparison with the effect of the V_o values, the O may be neglected. In silicate structures of similar types (e.g. in Na-Al-H and Ca-Al-H minerals) the presence of metal ions is particularly important for the optical properties. The n is greatly decreased by the zeolitic water, whereas other kinds of water do not show an essential effect.

265. J. M. Stevels

"A Simple Electrostatic Model to Assist the Study of Complicated Systems," Chem. Weekblad 43, 372-7 (1947); C. A. 41, 6378h.

An address on the modern interpretation of the structure and properties of glass systems. 7 figures.

266. M. Born

"Kinetic Theory of Condensed Matter," Research 1, 165-73 (1948); Cer. Abs. 31, 141.

A rigorous and general mathematical description of matter for any degree of condensation in terms of its molecular structure, has been formulated. 2 figures.

267. S. M. Cox

"Elementary Kinetic Theory of Dilute Silicate Glass," J. Soc. Glass Tech. 32 (149) 340-65T (1948); Cer. Abs. 32, 205.

From an argument based on the randomness of the ionic arrangement in glass and from kinetic considerations, the conclusion was reached that configurational changes are bound to take place in glass as the

temperature is changed. The distribution function associated with the randomness is assumed to be approximated by a two-cell histogram, and on this assumption approximate formulas for the thermal, viscous, and elastic properties of silica-rich glasses are derived. The formulas were applied to experimental results on Pyrex brand glass, and it is shown that there is a quantitative interrelation between the variations of thermal expansion, electrical resistivity and viscosity with temperature.

268. A. Dietzel and H. A. Sheybany

"Problems Related to the Filling of Structural Voids in Glass—Simple Alkali Silicate Glasses," Verres et refractaires, 2 (2) 63-80 (1948); Cer. Abs. 31, 221.

The solubility, dilatation, and density of alkali silicates were studied as a function of molar alkali content. Solubility in either water or diluted acids increases slowly with increasing alkali content up to a critical concentration ($20K_2O$, $28Na_2O$, or 35% Li_2O). A rapid increase in solubility is caused by further addition of alkali. This critical composition is correlated with a structure no longer isolating each alkali ion by SiO_4 groups. The density of lithium glasses is higher than that of silica by the same order of magnitude as the density of sodium glasses is higher than that of lithium glasses. The density of potassium glasses, however, is of the same order as that of sodium glasses because of the abnormally low ionic density of K+ in the alkali ion series. The dilatation curves exhibit the solidification of structure below the transformation point in the series Li-Na-K. Above the transformation point, dilatation remains constant regardless of an increase of alkali beyond 20% K_2O and 26% Na_2O. The $(SiO_4)^{4-}$ islands are believed to be separated by so many alkali ions that a further increase does not affect the dilatation. Ammonium was electrolyzed into glass successfully. Soon fissures caused a milky appearance of the glass, revealing the decomposition of NH^4 into $NH_3 + H_2O$.

269. Jean Gillod

"Modulus of Elasticity and Structural State of Glass," Verres et Refr., Feb. 26 (1948).

Dynamic method for E.

270. S. O. Morgan

"Principles Determining the Structure of Some Complex Ionic Crystals," Ceram. Age 52 pp. 276-80 (1948); Ceram. Abs. 32, 118.

Morgan points out the simplicity of the structures of many silicate minerals when interpreted with the aid of Pauling's rules. These rules have served to bring order into a field of apparently very complicated structures. The structures of many of these silicate minerals have been investigated by x-ray methods and provide excellent illustration of the rules.

271. N. V. Solomin

"Application of the Perodic Law of D. I. Mendeleev to the Properties of Glasses," Doklady Akad. Nauk S.S.S.R. 59 (4) 711-13 (1948); Cer. Abs. 33, 41.

Solomin attempts to compare effects of the equimolecular amounts of the components of glass. Comparisons were made with four silicate glasses. The functional dependence of the coefficient of expansion upon the structure of the atoms is not observed by making weight substitution, but it becomes apparent when making molar substitution and is in accordance with the periodic law. Both in the first and second groups of the periodic system there is an increase in the coefficient of expansion of the glass with increasing atomic weight of the metal. The dependence was more pronounced in the case of the refraction, particularly in the group of the alkali-earth metals.

272. J. O'M. Bockris, and J. W. Tomlinson

"Constitution of Silicate Melts," Research 2 (8) 326-(8 (1949); Ceram. 32, 241, 1949.

A review is given of the considerable but scattered literature on the properties of some inorganic salts in the liquid state, providing a progress report on the structural aspects of such melts, especially of silicates. Direct and indirect methods of investigation; experimental techniques including furnace construction, refractories, and temperature measurement; current theories of the structure of liquid silicates; and the applications of the postulated structures are covered.

273. Alexandre Laforgue and Denise Laforgue-Kantzer

"Free Valence, Anhydride Function, and Glass," Comp. rend. 228 1735-7 (1949); Chem. Abs. 44 (1) 1-37((1950).

Groupings XO_3 may associate if XO_3 has excess electrons and has a configuration different from an equilateral triangle. The groups XO_2 in associating arrange themselves symmetrically, with the result that the effective valence is not a whole number, but is given by the relation $L = V_{max.} - 3p$, where $V_{max.}$ is the valence attained by X in the neutral mol XY_3 and p is the index of bonding: $p = 2(x^2 + 12) - (\frac{1}{2})$. XO_3 groups exist as monomers if $L < 0.19$, as chains of a few groups if $0.07 - L = 0.22$, as glasses (infinite chains of tetrahedra) if $0.12 < L < 0.25$, and as rings in crystals if $L < 0.12$. The following ions (or mols) have the values of L noted: NO_3^- (0.01), CO_3^{--} (0.05), BO_3^{---} (0.07), SO_3 (0.12), PO_3^- (0.19), SiO_3^{--} (0.22), AlO_3^{---} (0.25), and SbO_3^{--} (0.43).

274. L. V. Tauson

"Lattice Energy of Silicates," Doklady Akad. Nauk S.S.S.R. 67 687-90 (1949).

Fersman (Geokhimiya *3* (1937) formulated the general geochemical principle that ion interaction accompanies a reduction of lattice energy and a free energy maximum. The Bowen reaction principle shows this rule may be significant in crystallization of magnetic systems. Lemmlein (C.A. *30*, 4373) calculated lower energies for mineralization products. By Bowen's reaction principle the first crystallization from magmatic melts are stable at higher lattice energy but are resorbed and recrystallized to lower lattice ener-

gies and stabilities. Free energy is a minimum if one of the intermediate minerals is crystallized, but increases in the subsequent members of the series apparently contradictory to thermodynamic principles. A table contains total lattice energy or typical silicate minerals from Kapustinkii formula. Apparent deviations from reaction principle rules are seen in micas and feldspars. They are thought to be due to partial replacement of Al^{3+} wor Si^{4+} in the structure unit.

275. N. N. Valenkov and E. A. Porai-Koshits

"X-ray Investigation of Glasses of the System Na_2SiO_3-SiO_2," Akad. Nauk S.S.S.R., Otdel. Khim. Nauk, i, Gosudarst. Ordena Lenina Opticheskii Inst., Sbornik Statei 1949, pp. 147-57 Cer. Abs. 36, 175 (1953).

Both tempered and crystallized glasses were x-rayed. The curves of the intensity of x-rays dispersed by the glasses have maxima corresponding to the position of the maxima of crystalline concretions of the same composition. The more intensive the preliminary heat-treatment, the sharper are the maxima and the more the x-ray image resembles that of the crystalline substance. Data indicate the presence in the glass of crystallites having the structure of definite chemical compounds. The presence of $Na_2Si_2O_5$ was not observed; this may be due either to its strong dissociation or to the similarity of its structure in the crystalline state to that of Na metasilicate.

276. Herbert Insley

"Problems in the Constitution and Fine Structure of Ceramics," Am. Ceram. Soc. Bull., 29 (1) 30-31 (1950); Cer. Abs. 33, 58.

The great extension of the use of highly specialized ceramics in novel forms of communication, transportation, and energy production has required an increased knowledge of the fundamental structure of these materials. The modern physical chemistry of the solid state can be applied effectively to ceramic materials. Examples are given of fundamental studies which had led to important technological advances, and brief consideration is given to unsolved problems concerning phase changes in silica and the silicates, the constitution of glassy and crystalline silicates, and the relation of constitution to electrical and thermal properties. 1 reference.

277. G. E. Rindone and W. A. Weyl

"Glasses as Electrolytes in Galvanic Cells: Silver Glasses," J. Am. Ceram. Soc. 33, 91-5 (1950); C. A. 44 (9) 3745-4288 (1950).

The behavior of glass as an electrolyte in galvanic cells was used to study the constitution of glass. Potentials were measured in cells made of alkali borate, silicate, and phosphate glasses containing heavy-metal ions. The magnitude of the potentials indicated the forces between the heavy-metal ions and the glass. Electrodes were of Pt. For Ag^+ glasses, cells of the type Pt/Ag^+ glass/Ag/Pt were formed by reduction of the Ag^+ ions in the vicinity of one electrode by H between 200 and 400°. The e.m.f.s. of these cells were of the order of 1.0 v. for silicate glasses, 0.7 v. for borate glasses, and 0.3 v. for phosphate glasses. The method has been found applicable also to glasses containing Pb^{++}, Sb^{+++}, and Bi^{+++}.

278. M. Fornaseri

"Structure of the Tetragonal Metaborates and Their Crystal Relations," Ricerca sci. 21, 1192-4 (1951).

Teepleite and bandylite both contain tetrahedral $B(OH)_4$ groups. Although they are formulated $NaB_2O_4 \cdot 2NaCl \cdot H_2O$ and $CuB_2O_4 \cdot CuCl_2 \cdot 4H_2O$, no H_2O groups occur in the lattice, only OH groups. Diagrams of their structure are given.

279. Stig Lindroth

"Structure of Glass," Glastek. Tid., 7 (1) 3-5 (1952).

Lindroth summarizes fundamental data on the structure of glass. He suggests the terms "tektogen" for network formers and "tektotrop" for network modifiers. 5 figures.

280. Stig Lindroth

"Structure of Glass," Glass, 29, 229-230 (1952).

There are three types of glass formers: (1) Atom-ion bond, as found in oxides, sulphides, halogenides, silicates, silicones. (2) Atom-molecule bond as in organic polymers, alcohols, sugars. (3) Atom-metal bond, e.g., arsenic, antimony, selenium, tellurium; chain bonds also occur in this latter case. Transition types between these three groups are also possible, so that there is no sharply defined boundary between "ordinary" glass and Plexiglass. Glass is therefore, according to Smekal's definition, a substance which contains "mixed" bonds. Dietzel has proposed the group name "vitroids" for all glass-like substances. The author prefers the name "hyaloids," and formulates the following definition: A hyaloid is a compact, physical homogeneous substance in an amorphous state, which is hard and brittle at low temperature but softens on heating. The answer to the question "What is glass?" is therefore "An inorganic industrial product in the hyaloidal state."

281. S. Bateson

"Note on the Structure of Glass Fibers," J. Soc. Glass Tech., 37, (179) 302-305T (1953).

Bateson discusses the discrepancy between the theoretical and practical mechanical strength. Profound structural modifications must account for the unique properties of fine fibers. 7 references.

282. Sven V. Berger

"Crystal Structure of Boron Oxide," Chem. Scand., 7 (4) 611-22 (1953). (In English).

The crystal structure of B_2O_3 has been determined by trial-and-error methods. The unit cell contains three formula units and belongs to the space group C_3^1 (C_3^3). Dimensions and atomic parameters are given. The structure is built up of two sets of BO_4 tetrahedra forming interconnected spiral chains of two types running parallel to the trigonal axis. Within each tetrahedron the strength of one B--O Bond equals unity, and the strength of the remaining three bonds equal two thirds of unity. 5 figures, 9 references. *(To be continued in April)*

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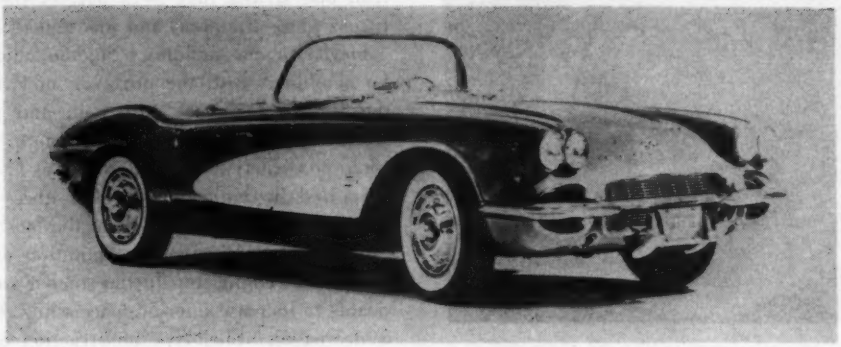


Fig. 1. More than 43,000 Chevrolet Corvettes are on the highways, proving that fiber glass reinforced plastic makes an excellent car body—strong, light, durable, corrosion-resistant. This is the 1961 model.

FIBER GLASS a Challenge for The Automotive Industry *

by *Irwin J. Gusman*, Manager, Industrial Glass Fabrics Dept., J. P. Stevens & Co., Inc.

FIBER GLASS reinforced plastics offer a two-fold challenge to the automotive industry — a challenge to recognize the immediate advantages of structural plastics in today's cars and a challenge to explore the full potential of the materials in designing the cars of the future.

It is an established fact that fiber glass reinforced plastic makes an excellent car body. Chevrolet has more than 43,000 Corvettes on the road to prove that it offers motorists a well-styled, corrosion-resistant, strong, light body. But the economics of car manufacturing are such that even a superior material must match, or better, the cost of the material it replaces. Fiber glass reinforced plastic costs more than steel, pound for pound, and usually takes more time and labor to fabricate. However, it is the total fabricated unit cost that is important, and here we believe fiber glass offers unique opportunities.

In compensation it has two big cost advantages: *(1)* much lower tooling cost and *(2)* a moldability that permits reduction in number of parts. Today, on the average, it is possible to build about 25,000 fiber glass bodies before the higher material and fabrication costs deplete the saving on tooling. This break-even point has risen steadily. As resin and glass prices have dropped, steel prices have gone up, and plastics processing has improved. A few years ago, molding cycles for typical fiber glass parts were 3 to 5 minutes — today, the same parts can be formed in 20 to 50 seconds. It is safe to predict that the engineer who starts today to design a structural plastic body will have improved resins, better glass, and faster, more automated fabrication to help him before he is through.

The Corvette program has operated profitably within this economic volume limitation. The growing segmentation of the automotive market and the proliferation of models may well mean that there are other opportunities right now for profitable production of fiber glass reinforced plastic car bodies.

The weight-conscious trucking industry, with its many models and low production totals is a natural market for fiber glass, and we observe its increasing use for truck cabs by White, Brockway, Ford, and for truck bodies by Heil and others. Stevens high modulus glass fabric will be fabricated into panels by Continental Can Company as a liner for the cargo section of the new Boeing 727 medium range jets. Weight savings and impact resistance were prime requirements.

There is evidence, though, that fiber glass reinforced plastics can transcend volume limitations by use of its second cost advantage — the ability to reduce the number of parts required. We can have a fiber glass heater duct because it can be molded in fewer pieces than metal requires, and we save money on assembling the pieces.

We can have a phenolic-glass headliner on the 1961

*Delivered at the 16th annual technical and management conference, Reinforced Plastics Division, Society of the Plastics Industry, February 7-9, Chicago, Ill.

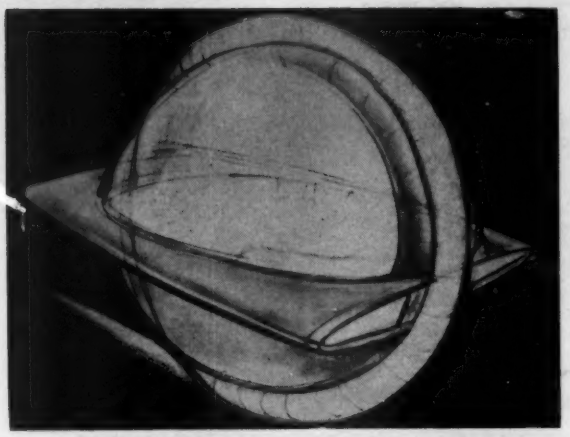


Fig. 2. Designers and engineers are calculating the possibilities of a uniwheel car with a gyro-stabilized fiber glass-plastic body inside a single big fiber glass tire with 200,000-mile tread life.

Rambler because this one piece replaces framing, fasteners, insulation, and fabric, since it can be snapped in place quickly and economically. Here, the cost per pound of resin and glass, the slowness of the molding cycle, the labor cost per unit — all these were overshadowed by the greater savings achieved when imaginative design engineers utilized the inherent advantages of the fiber glass and plastic materials.

Please observe that this kind of advance can be achieved with today's materials at today's prices on today's fabrication equipment. But at every Reinforced Plastic Division technical conference we hear reports on improvements in materials and processing. One of the forerunners of new, higher-performance reinforced plastics materials now coming out of the research laboratory is a new high-modulus glass fiber containing 8 per cent beryllium oxide. This new glass formulation results in fibers with 50 per cent higher modulus of elasticity than present glass fibers used for reinforcing plastic material. When this beryllium oxide glass composition is imbedded in the plastic matrices, it provides impressive improvements in rigidity without sacrificing strength.

Whether in single fiber glass parts that replace several pieces of other materials or in all-fiber-glass bodies, the industry needs to take full advantage of possible parts reduction. The Corvette has about 80 body parts in spite of some impressively large moldings like the one-piece underbody. But I understand that the people who make the Corvette body, the Molded Fiber Glass Body Co., collaborated with Creative Industries on a compact car design that calls for just *eleven* body parts. This is conceived as a practical, economical product, conventional in appearance, suitable for today's market.

Even this is not the ultimate. Simple monocoque or shell-like constructions can be achieved with inherent strength and rigidity. Whatever framing or stiffeners are required can be molded in. There is ample precedent for this in current practice. I'm sure most of you know of boat hulls as large as 17 feet produced in one piece on matched metal molds with FRP framing molded in.

We see a one-piece headliner today. Why not go a step further and combine roof and headliner? Interior trim and styling may be a part of the body shell. The trunk, spare tire well, and gas tank conceivably can be achieved in one molding. So, too, might the floor pan be combined with the covering material. In addition, the instrument panel, fire wall, and plenum chamber will be molded as one piece. The doors may be of sandwich construction with decorative fiber glass facings supported by high-strength fiber glass honeycomb.

All of us are well aware that the lack of interior space is becoming an increasing limitation to the automotive stylists and engineers. In the smaller car types, it is desirable to increase interior space while the outer envelope is decreased. Shell-type construction is an answer.

When we *do* have to assemble parts, we'll do it swiftly, cheaply, and permanently with adhesives. There's nothing visionary in that — the parts of the White truck cab, for example, are bonded together, as are many parts of today's modern jet aircraft. I wonder how cheaply we could produce a preimpregnated glass fabric if some car manufacturer decided to use it for automated high-volume production.

So far we have been talking about cars to meet today's requirements, about the advantages of reinforced plastics in a fairly conventional vehicle. But we are teetering on the edge of a new technology of transportation, on the threshold of a world in which the advantages of our materials will be magnified.

It appears to us, looking in on this dynamic automotive industry, that it is again in the midst of a major transition in designing and engineering. Every automotive engineer has done some serious soul-searching about the car of tomorrow; the impact of fuel cells on body engineering; the lessons of space-propulsion; the penetration of electronic devices in automobile travel; the emergence of electroluminescence; advance thinking in fluid mechanics and systems; developments resulting from the field of cryogenics and advanced semiconductors; and the potentials of microwave, sonic, solar and infrared forms of energy. The industry has been researching new modes of transportation which include ground-effect machines or air-cushioned cars; uniwheel vehicles, amphibian and triphibian cars.

In tomorrow's highly versatile vehicles, lighter weight and greater strength become imperative. These versatile machines will demand that structural strength be built in, to assimilate entirely different types of stresses and strains connected with each varying type of travel. It is obvious that abuse from rough landings, buffeting waters and ground bumps will require an unprecedented combination of strength and resistance factors in a single body structure. Not only will a light body material be essential in the future, but weight saving *here* and *now* is a cumulative blessing. A pound saved in the body shell permits you to use a smaller and lighter engine to accelerate the car, smaller and lighter brakes to stop

it, smaller and lighter tires to support it, a smaller freight bill to transport it, and a small fuel bill to run it.

Tomorrow's Possibilities

Let's look at some of the possibilities in tomorrow's transportation and see how growing requirements for low density and high strength increase the probability of a switch to fiber glass reinforced plastics.

FLOTATION SYSTEMS which may be important in some vehicles of the future, need not be added appendages, since they can be built into the body, possibly through the use of sprayed-on foam sandwiches.

AIR FOILS in smooth-flowing designs and easily maintained polished surfaces, will be needed and available in low-density, high-strength plastics.

THE UNIWHEEL is clearly predictable. The necessity for lightweight functional design is essential since that conveyance will be held upright by gyroscopic devices. This gyro-car, operating on a single massive tire, must be built for maximum strength and minimum weight in order to provide room for the electronic gear which most of our future cars are likely to contain. The tire, with a projected tread life of 200,000 miles, could well be cast from a liquid resin resulting from a chemical reaction between a polyether glycol and a polyisocyanate, reinforced with a two-phased glass fiber, with a tread-coating of fluorocarbon.

NEW TYPES OF POWER SYSTEMS are matters of top priority today. These systems will be highly efficient in their energy conversion, weight factors, or both. Such power systems include the fuel cell, solar battery, gas turbine, thermionic converter, nuclear energy, solid fuels, and even the plasma jet source. Some of these exotic power systems will demand high strength, high-temperature-resistant materials.

ADVANCED MANUFACTURING TECHNIQUES will enable tomorrow's engineers to incorporate many functional parts in the auto body. It will be possible to integrate entire exhaust systems (if exhaust systems are still used) into the body. The muffler might be composed of glass fibers or fibers of advanced heat-resistant substances, such as titanium salts, which might be consolidated into the plastic matrix.

SPRING TORSION-BAR SYSTEMS will become an integral part of the body, since it has already been demonstrated that strength and elastic properties of glass fiber reinforced plastic materials have made possible such highly stressed applications as springs. Picture if you will a body shell of fiber glass reinforced plastic moving down a computer-controlled assembly line with spring and exhaust systems already fabricated into the structure. The electrical system could then be added, not by hanging on a multiude of harnesses, wiring systems, relays and the like, but rather, by means of a printed circuit which could be automatically painted on to the plastic body structure. As you know, glass fabric reinforced plastics are one of the standard materials for printed

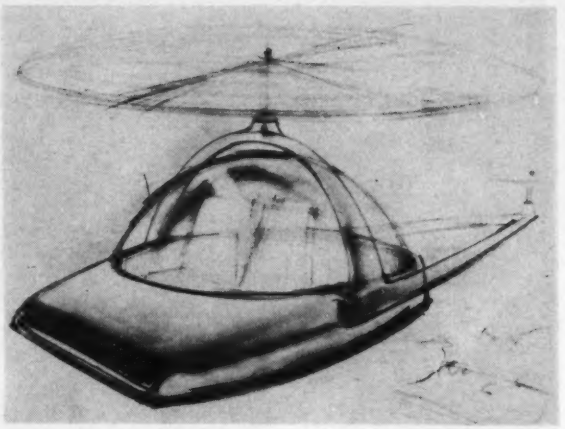


Fig. 3. Vehicles of the future like this triphibian will need the light weight and ruggedness of fiber glass to meet the varied problems of travel on land, air, and water.

circuit boards. In addition to the printed circuit, it is not inconceivable that certain other advances contributed by solid-state physicists and the astonishing electronics industry, could result not only in the distribution of electrical power through the body, but also accomplish the function of electro-mechanical generators, relays, and other circuit devices. These might be carried out as solid-state reactions within materials molded into the plastic body.

If our futuristic car contains the engineer's dream of *one single fluid* for all of the cooling, braking, steering, and other power functions, the single master fluid will undoubtedly be sealed into a fiber glass-plastic unit molded into the body structure. This would involve integration of molded-in duct work which could be accomplished by pre-forming tubes into the structure that should never leak or shake apart.

Future Styling

In your new concept of tomorrow's cars, let us now contemplate the radically new styling effects that might be obtained through the use of fiber glass. New configurations will be possible that heretofore could not be fabricated in steel.

It is also conceivable that not only color but surface finish can be impregnated in to the reinforced plastic material during the molding of the body shell. Such wax-like impregnations might be chemically devised to migrate gradually to the surface, and provide the car with a perpetually colorful and attractive finish.

In the area of esthetics, certain built-in lighting effects could be accomplished by day or night. It would become possible to style a permanent bubble-top which could be either semitransparent, translucent, or completely opaque by controlling the polarization of light that would otherwise be admitted. Another possibility might be found in the research and development work being done with phototropic materials which are color-sensitive to

(*Continued on page* 169)

NEWS

M. T. Nemeyer (left), Owens-Corning sales manager, reinforced plastics division, presents the Design Award to James S. Lunn (center) who holds a model of the winning boat, while William T. Cruse, executive vice-president, Society of the Plastics Industry, looks on.

Owens-Corning Sponsors Design Award

The first annual Reinforced Plastics Design Award sponsored by Owens-Corning Fiberglas Corp. was presented to James S. Lunn, president, Lunn Laminates, Inc., Huntington Station, N. Y., at the 16th annual Technical and Management Conference, Reinforced Plastics Division, Society of the Plastics Industry. The firm won the award for a whaleboat produced for the U. S. Navy and designed by the Navy's Bureau of Ships. The award, a crystal sculpture, "Counterpoise," by Steuben Glass, was presented on the basis of utility, moldability, appearance, material selection, color, and originality of application or design.

Brunswick Corp.

Is enlarging its fiber glass boat building capacity to satisfy increasing demands. The expansion will be at the company's plant in Little Falls, Minn.

Ferro Corp.

Reported 1960 its second-best year despite a 3.7 per cent drop in consolidated sales and a 23.3 per cent decrease in net income. Sales totaled $61,467,000 as compared with $63,846,00 for 1959, and income was down from $3,331,000 for 1959 to $2,556,000 for this past year. Earnings based on 816,057 shares outstanding for both years were down from $4.08 to $3.13 per share.

Kaiser Gypsum Co.

Has been named by Owens-Corning Fiberglas Corp. as its Pacific Coast fiber glass screening distributor. The screening, made of vinyl-coated fiber glass yarns, will be sold through local distributors of building materials in Kaiser's 14-state marketing area.

Robert W. Dobson

Robert W. Dobson

Manager, Defiance Carpenter Road plant, Johns-Manville fiber glass division, succeeding R. H. Barnard, Jr., who has been transferred to the firm's sales organization in Chicago. Dobson, with the company since 1941 when he began as an industrial engineer at the Manville, N. J. plant, has served as methods engineer, methods section supervisor, production engineer, and most recently, manager of the industrial insulation plant at Manville.

Molded Fiber Glass Companies Integrate Sales

The Molded Fiber Glass Co., the Molded Fiber Glass Body Co., and the Molded Fiber Glass Sheet Co., all of Ashtabula, O., have consolidated their sales staff under the direction of Jack R. Hammond, new general sales manager. Burrit S. Hubbard, formerly factory manager of the Ashtabula Bow Socket Co., has been named assistant to the president, succeeding Hammond who was also treasurer of the firm.

Lorin Palmer has been made manager of automotive sales with headquarters in Detroit and Frank Orr will be in charge of all sales to truck body and trailer manufacturers.

Dr. Piero Modigliani

Consultant in the fields of fiber glass and reinforced plastics, Modiglass Fibers, Inc., a division of Reichhold Chemicals, Inc. His time is divided between New York, where he acts as technical adviser to RCI and Modiglass, and Milan, Italy, where the Laboratorio Piero Modigliani is now located. Modigliani, who maintains his own offices in both cities, is an early researcher in these fields, and in 1932, developed "Thermolux" glass in Italy.

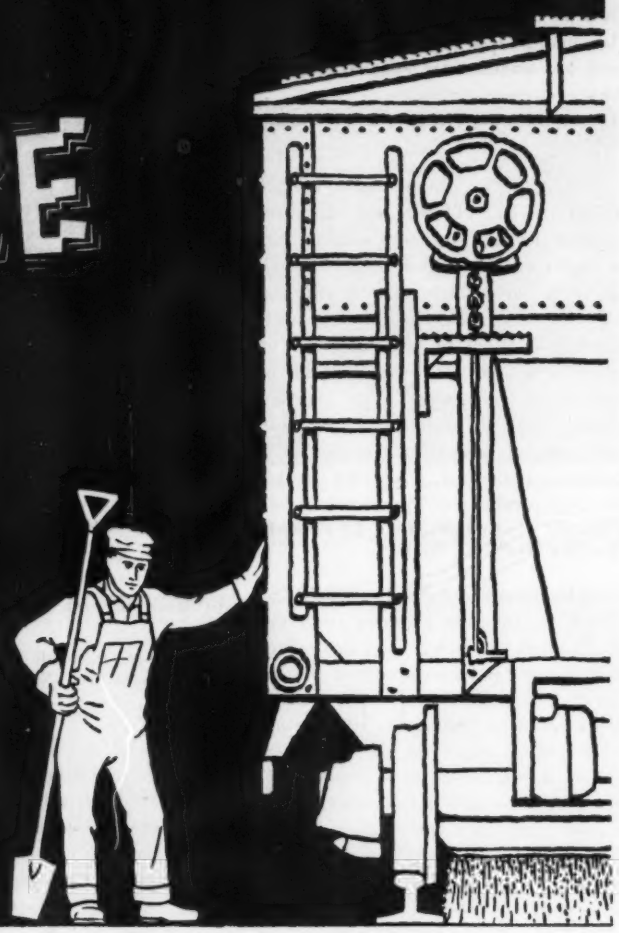
Louis R. Kessler

Louis R. Kessler, Operations vice-president of Owens-Corning Fiberglas Corp., died January 20. He was 51.

Kessler joined Owens-Illinois Glass Co. in 1931 as an engineer in the firm's Alton, Ill., plant, and in 1942 was named eastern factories manager. In 1944, he was made general factories manager for the company's Oakland and Los Angeles plants, and was later made assistant to the vice-president in charge of engineering. With Owens-Corning from 1946 on, Kessler served as engineer in charge of designing, constructing, and organizing the Santa Clara, Calif., plant, vice-president of the corporation, and general manager of the Pacific Coast division.

He was appointed vice-president and general manager of the firm's general products division, headquarters Toledo, O., in 1957, and in May of 1959, was named operations vice-president with responsibility for all manufacturing and marketing operations of the corporation.

NOT A
SNEEZE
IN A
CARLOAD



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Applications...

FIBER GLASS CLOTH designed for ease in laminating deep, sharp contour surfaces has been introduced by Rezolin, Inc. It is claimed that the material, called "Drapeze No. 319", allows faster laminating, less layers at lower costs, and less interlaminar residual stress in sharp contour laminates.

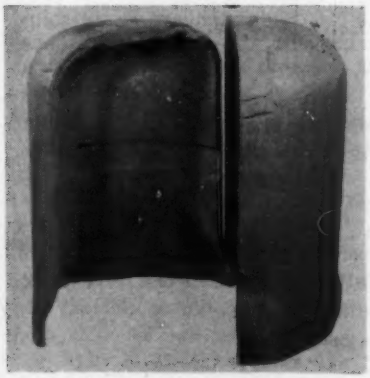
Glass: Rezolin, Inc., Santa Monica, Calif.

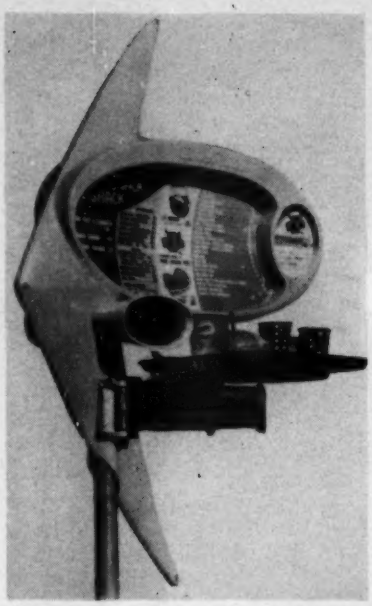
PROTECTION AGAINST FIBER GLASS IRRITATIONS, one source of contact dermatitis, is now available as a cream called "Kerodex #71" which prevents sensitization of the skin by sticky epoxy resins and amine hardeners, and offsets the irritant action of glass wool particles widely used in laminating procedures. This barrier cream, specially formulated for wet operations, is also on the market in a companion product, "Kerodex #51," for dry operations.

Creams: Ayerst Labs, Inc., 22 E. 40th St., New York 16, N. Y.

FIBER GLASS NOISE SURPRESSORS designed for compact room air conditioners are being used to deaden high-frequency noises produced by the compressors within the units. Made of vinyl-coated fiber glass, these two-piece covers eliminate the need for pasted insulation parts and are easy to install. The insulation density of the molded units is about 6 pounds per cubic foot, allowing a maximum of acoustical insulation with a minimum of weight and bulk. Similar items are being used in numerous appliances, electronic chassis, airborne and missile-borne instruments, and other critical applications.

Glass and Design: Fibrous Glass Products, Inc., subsidiary of Pall Corp., Alpa Plaza, Hicksville, N.Y.





DRIVE-IN ORDER STANDS designed with fiber glass bodies mounted on steel pipes and concrete bases are being used to modernize the operation of car-hop restaurants.

Fabricator: Car-Call Electronic Ordering Systems, 249 N. 48th St., Lincoln, Neb.

FIBER GLASS CORES are being used in 2-watt lead-axial wire-wound power resistors. Resistance elements of the new units are wound tightly and uniformly on these cores, and copper leads are secured to the elements. The assemblies are sealed in rectangular ceramic cases which provide a protective bond between the resistance elements, terminals, and cases. The "PW-2" resistor is claimed to be fireproof in construction, and will have wide application in radio, TV, and industrial circuits.

Development: International Resistance Co., 401 N. Broad St., Philadelphia, Pa.

ISOLATION PADS made of specially processed high-density fiber glass are being furnished in 18- by 18- by ½-in. sheets, pre-scored in 2-in. sections. These pads are said to be highly efficient in isolating machinery vibration and to eliminate cementing, sawing, and floor drilling in installation.

Glass: Owens-Corning Fiberglas Corp., Toledo, O.

Fabricator: Consolidated Kinetics Corp., 1065 Dublin Rd., Columbus 12, O.

CHOPPED STRAND FIBER GLASS MATS have been developed by the fiber glass division of Pittsburgh Plate Glass. These mats are said to possess exceptionally good wet-out characteristics which add translucency and reduce fiber pattern in reinforced plastic products. The product will be made available in all standard weights and widths up to 76 in., and is applicable for corrugated translucent structural panels, boat manufacture flat laminates, and molded parts constructed with matched metal dies.

Glass: Fiber Glass Division, Pittsburgh Plate Glass Co., One Gateway Center, Pittsburgh 22, Pa.

FIBER GLASS REINFORCED GUMMED TAPE contributes to the reuse of cartons and boxes by leaving a negligible build-up of kraft fiber even after 25 re-taping operations.

The tape is non-asphaltic and has a top layer of reinforced construction that can be ripped off the carton, which leaves a thin kraft layer that can be "popped" easily to open the carton. The tape meets all Rule 41 requirements for two-strip carton closures.

Tape: Mid-States Gummed Paper Div., Minnesota Mining and Mfg. Co., 6800 S. Harlem Ave., Bedford Park (Argo P.O.), Ill.

FIBER GLASS structural sandwich building panel can be used as curtain walls, exterior wall panels, interior partitions, roof panels, skylights, canopies, room dividers, screens, and translucent roofs for covered areas.

The panel consists of two skins of fiber glass reinforced plastic laminated to an extruded aluminum grid-work core. Permanent lamination is accomplished by means of a rubber based bonding adhesive which is activated by heat and pressure. All edges of the skins are covered by an integral aluminum lip for maximum protection.

A catalog with detailed descriptions and illustrations is available showing a series of grid patterns and an illustration of panel installation on the new Stamford Senior High School, Stamford, Conn., which represents the largest installation of translucent fiber glass reinforced plastic wall panels in the United States. The catalog is free.

Panels and Catalog: Panel Structures, Inc., 45 Greenwood Ave., East Orange, N.J.

NEWS
IN THE GLASS INDUSTRY

TOLEDO AWARD IN PICTURES

Presentation of the Award: (left to right) Archie N. Solberg; Delos Palmer, Chairman, A.C.S. Northwestern Ohio Section; Oscar G. Burch, vice president of engineering and research, Owens-Illinois Glass Co., and Award winner; and Milton Adams, chairman, Awards Committee.

The 1961 Award Vase, designed by Edwin W. Fuerst, Tiffin, O., with Blake-More Goodwin, former Director of the Toledo Museum of Art, as consultant.

Symposium speakers, left to right: J. R. Hanson, Castle-Hanson Glass Co.; Fred M. Merritt, Toledo Engineering Co.; J. P. Poole, Brockway Glass Co.; C. L. Babcock (Moderator), Owens-Illinois; R. W. Hopkins, Columbia-Southern Chemical Corp.; Sherman S. Weidenbaum, Corning Glass Works; and R. S. Arrandale, Thatcher Glass Co.

Toledo Glass and Ceramic Award Dinner, held January 23 in the ballroom of the Commodore Perry Hotel at Toledo.

Carl Megowen, president, Owens-Illinois, speaking at the Award Dinner on the accomplishments of Oscar Burch.

Personalities...

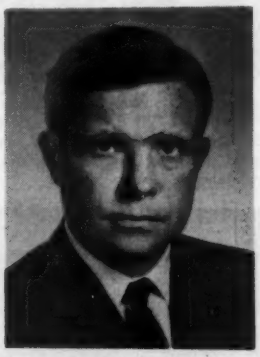
Joseph C. Littleton

Joseph C. Littleton

Manager of new products search, new products division, Corning Glass Works. Justin Lubold succeeds him as manager of the Big Flats, N.Y., plant.

Littleton joined the company in 1945 as an engineer, served four years as a production and maintenance supervisor, and two years as manager of the optical plant. In 1955, he was named manager of the apparatus plant, and has been plant manager at Big Flats since 1957.

Lubold has been with the company since 1957, first as a project engineer, and from 1959 until his recent appointment, as production superintendent at the Muskogee, Okla., plant. He will be succeeded by Robert H. Martin.



Justin Lubold

Joseph H. Lewis

Executive vice-president, American-Saint Gobain Corp. He was formerly vice-president in charge of the company's Blue Ridge Glass Division. The firm is contemplating relocation of corporate headquarters in Kingsport, Tenn.

Dr. Atma Ram

Director of the Central Glass and Ceramic Research Institute, Calcutta, India, has been awarded the first Shanti Swarup Bhatnagar Medal (1959) in the Silver Jubilee celebrations of the National Institute of Sciences of India inaugurated by Prime Minister Nehru, December 31, 1960. The medal, to be awarded every third year in recognition of work outstanding in merit, was presented by the president of the Institute, Prof. S. K. Mitra, F. R. S.

Ram represents India on the International Commission on Glass, and the award which he received is the National Institute's highest distinction in the field of applied sciences. The medal commemorates the late Sir S. S. Bhatnagar, F. R. S., past president of the Institute and the first director-general, scientific and industrial research.

DeForest Bowman

District sales manager, Brockway Glass Co., for the firm's new Nebraska territory. With Brockway since 1955, he was formerly Southwest regional sales manager for prescription wares, headquarters in Dallas, Tex.

A. M. Young

Manager, marketing department, Libbey-Owens-Ford Glass Co. In this newly-created position, he will report to E. R. Pierce, vice-president, distributor sales, and will be responsible for formulating marketing programs for all of the company's major products.

Harold J. Yerger is sales promotion manager, reporting to J. M. Ashley, vice-president, public relations.

A. C. Bolderman is regional sales manager, Pacific area, with headquarters in San Francisco. His territory includes the states of Washington, Oregon, California, Idaho, Nevada, Utah, Arizona, Colorado, and parts of Montana, Nebraska, New Mexico, and Texas.

Frederick R. Suckow has become district manager of distributor sales in Los Angeles. Eldon M. Williamson, Jr., succeeds Suckow as district industrial manager in that area.

J. S. Nordyke

J. S. Nordyke

President of the American Ceramic Society, will be inaugurated at the 63rd annual meeting (April 23-27) in Toronto, Canada. He will be the first man of Canadian birth to head the nearly 8000 ceramists who participate in the world's largest organization dedicated to the advancement of ceramic science and technology.

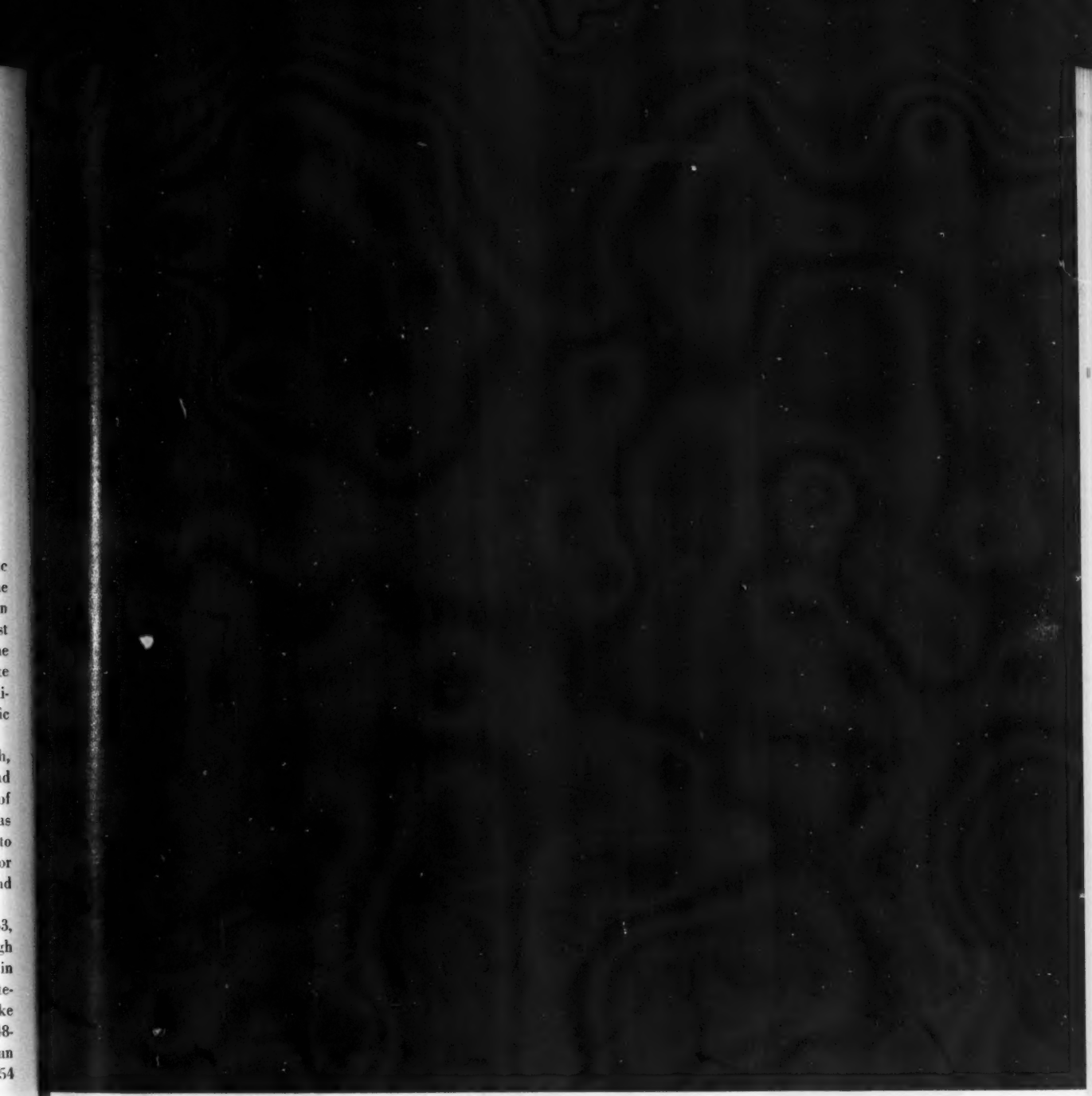
Nordyke, presently of Pittsburgh, Pa., is director of sales for Hammond Lead Products Co., Inc., producer of lead-base chemicals, with whom he has been associated since 1953. Prior to that, he served Eagle-Picher Co. for 22 years in production, research, and sales.

A member of the Society since 1943, he became secretary of the Pittsburgh section in 1946-47, and chairman in 1947-48. As an affiliate of the materials and equipment division, Nordyke held the position of secretary in 1948-49, vice-chairman in 1949-50, chairman in 1950-51, and trustee from 1954 through 1957.

He was made a Fellow of the Society in 1955, and elected to a term as vice-president in 1957-58. He has also served as chairman of the committees on student branches, sections, and membership. Last year, Nordyke acted as counselor of the Pittsburgh section, and is currently a member of the Society's executive committee.

Peter B. Obbard

Manager, Pittsburgh Plate Glass Co.'s Tucson, Ariz., service branch, succeeding Howard E. Tracy, who has been made manager of the firm's branch in Albuquerque, N. M.



KAISER PERICLASE BRICK: STRONG BREATH OF LIFE IN A GRAVEYARD OF CHECKERS

Scene: inside a sodium silicate regenerator. Time: after a two-year campaign. At the center of the picture, a narrow test setting of Kaiser Refractories' Periclase checkers stands alone. Clean. Flues wide open.

In the foreground and background you can see an eroded jumble of competitive super-duty high burned brick that once stood just as high ... now choking the life out of a campaign.

This test section just four flues deep set with Kaiser Periclase D unburned in the top five courses and Periclase A unburned below, proved to one furnace operator the superiority of these brick. And in many, many more installations, Kaiser Periclase brick are making glass furnace history—with campaigns up to five years, saving thousands of fuel dollars which repay added checker cost many times over.

For information about basic or fireclay refractories, contact your Kaiser Refractories Sales Engineer or write to Kaiser Refractories & Chemicals Division, Kaiser Aluminum & Chemical Sales, Inc., at any of the Division Offices listed below:

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High Alumina, Fireclay, Graphite and Silica Refractories, Periclase Brick, Mortars, Grains and Ramming Mixes

Earl A. Garber

Earl A. Garber

Chairman of the board, Harbison-Walker Refractories Co., and A. Brent Wilson, president, succeeding Garber who will continue as chief executive officer of the company.

Garber began with Harbison-Walker as assistant foreman in the mines where he also served as foreman and plant superintendent and district superintendent of the works department. He was later made manager of Northwest Magnesite Co., a subsidiary, of which he became vice-president and general manager in 1944. In 1947, he was named vice-president and general manager of Harbison-Walker, and since 1948, has been president of the firm.

Wilson, a metallurgical engineer, was first associated with the company as an employee of Canadian Ltd., a subsidiary. In 1948 he was made general manager there, and in 1950, was transferred to Pittsburgh as assistant to the president of Harbison-Walker. He became vice-president of the parent Harbison-Walker Refractories Co. in 1955, and has served as executive vice-president since 1958.

A. Brent Wilson

Stanley B. Honour

Sales manager, International Division, Diamond Alkali Company.

Hans R. Dolf

Group leader, and John Massier and Robert J. Casey, assistant group leaders, at Selas Corp. of America, Dresher, Pa. Massier will be working under Dolf in the investigation of oil combustion and heat processing as applied to the glass and food industries, and Casey will engage in studies of gas combustion and burner development under the direction of Charles Morck.

Dr. N. J. Kreidl

Director of materials research and development, Bausch & Lomb Inc., has been reappointed for a term of two years to the Academy of Science, National Research Council's advisory panel to the National Bureau of Standards, mineral products division.

Dr. Robert H. Reed

Vice-president, development, Solvay Process Division, Allied Chemical Corp. Announcement of Reed's appointment coincides with a major expansion of Solvay's research facilities at Syracuse, N.Y., where he will continue to be in charge of research, engineering, technical service, and market research.

In his new capacity, he has named Dr. Elwood Booth, Jr., assistant director of research, Dr. Edward R. Degginger research supervisor, and Dr. Michael J. Skrypa associate research supervisor.

Frank H. Bower

Manager of research and development contracts, semiconductor division, Sylvania Electric Products, Inc., a subsidiary of General Telephone & Electronics Corp.

M. J. Morray

Sales manager, and Charles A. Berridge, sales representative, with headquarters in Downey, Calif., silicone products department, General Electric, Waterford, N.Y. Morray will be responsible for 14 sales offices throughout the country. He succeeds Thomas J. March who has taken a new post as manager of the company's newly-established internal automation operation in Schenectady.

Hon. Amory Houghton

Shortly to resume his post as chairman of the board, Corning Glass Works, following retirement as United States Ambassador to France.

William S. Dando

Sales representative, Libbey-Owens-Ford Glass Company in Philadelphia.

Willam A. Skinner

Designer, architectural service department, Libbey-Owens-Ford Glass Company.

Donald A. Tylor

Appointed a dairy pipe sales representative for Corning Glass Works.

Harold E. Pink

Harold E. Pink

Vice-president, and John B. Hanson, general sales manager, Cambridge Wire Cloth Co. Both men will aid in the coordination and advancement of company plans to expand operations at the Cambridge plant and in territories across the country.

Pink, after serving seven years as factory apprentice and office clerk, was appointed sales manager of the wire cloth division in 1940, and since 1944, has been assistant to the president in charge of the division. Hanson, who became manager of internal belt sales at the Cambridge plant in 1959, will

John B. Hanson

direct the firm's twelve sales engineering offices throughout the United States, Canada, and Mexico.

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Frank H. Wheaton, Jr.

Frank H. Wheaton, Jr.

Elected to the board of Directors, American Can Co. Wheaton is president of the American-Wheaton Glass Corp., a recent joint venture in which American Can holds the majority interest.

Henry Byrne

General sales manager, Raymond F. McHugh & Son, Philadelphia, manufacturers of pyrometers and thermocouples.

Michael Karp

With Vitro Chemical Co. as market analyst, reporting to the market research manager. Formerly a member of the faculty of the University of Pennsylvania, Karp has been employed as an economic analyst by Eastman Kodak, and by Thomassen & Drijver, Deventer, Holland.

Donald M. Black

Manager of development and market research for Diamond Alkali Company.

Don F. Webb

Retired December 31, 1960, having been Chicago district distributor sales manager for Libbey-Owens-Ford Glass Company since 1942. He has been in the flat glass industry 40 years, since his first job in January, 1920, with Sharp, Partridge & Co., a former Chicago glass jobber. In 1928, he became sales representative for Blue Ridge in Detroit, covering Ohio and Michigan.

When L-O-F became sales agent for Blue Ridge, Webb joined the firm as a sales representative in Chicago and was a member of the company's special task force which helped achieve public acceptance of safety glass in cars.

Dr. John J. Bohrer

Elected a Fellow of the New York Academy of Sciences in recognition of his "outstanding work toward the advancement of science." He is director of research for International Resistance Co., and author of numerous technical studies on copolymerization and organic semiconductors, among other subjects.

Harry F. Welch

Manager of economic control for the general manufacturing department, Owens-Illinois Glass Co., glass container division, effective March 15. He has been director of industrial relations for the firm since 1956, and prior to that, served as supervisor of wage and salary structure, to which post he was named in 1940.

Effective on the same date is the appointment of Andrew Menzie, formerly personnel director at the Streator plant, as director of industrial relations for the division, headquarters in Toledo. In addition, Edward F. Wendle has been promoted to the newly-created position of production manager for the company's Alton, Ill., container plant.

Joseph G. Shick, Jr.

Received Pemco's Heinrich & Karl Turk Merit Award for his development of a new process for quality control of vitrifiable glass colors. In addition to a bronze plaque presented by Richard Turk (chairman of the board), Schick, a member of the color manufacturing department, received a $500 savings bond. Two other awards in the same amount were given to Michael Friesner of the customer service laboratory and Robert Ott of the research laboratories for outstanding contributions to the company in 1960.

Richard Turk (left) presents the Pemco Merit Award to Joseph G. Schick, Jr.

John P. Gleason

John P. Gleason

Manager of the Washington office, Owens-Illinois Glass Co. He succeeds Walter G. Thomas who has held the position for 16 years and is retiring after 33 years with the company.

With the firm since 1950, Gleason was sales manager for the electronic products division of Kimble Glass Co., a subsidiary of Owens-Illinois, from 1954 until 1960. During 1960, he served as assistant director of mobilization planning for the containers and packaging division, Business & Defense Service Administration, Department of Commerce.

George W. Read

Marketing manager for Du Pont's "Butacite" polyvinyl butyral resin, the inner layer in safety glass. He succeeds Fred E. Wintzer who has been transferred to Du Pont de Nemours International S. A., the company's Swiss subsidiary.

Jose Joaquin Quintero

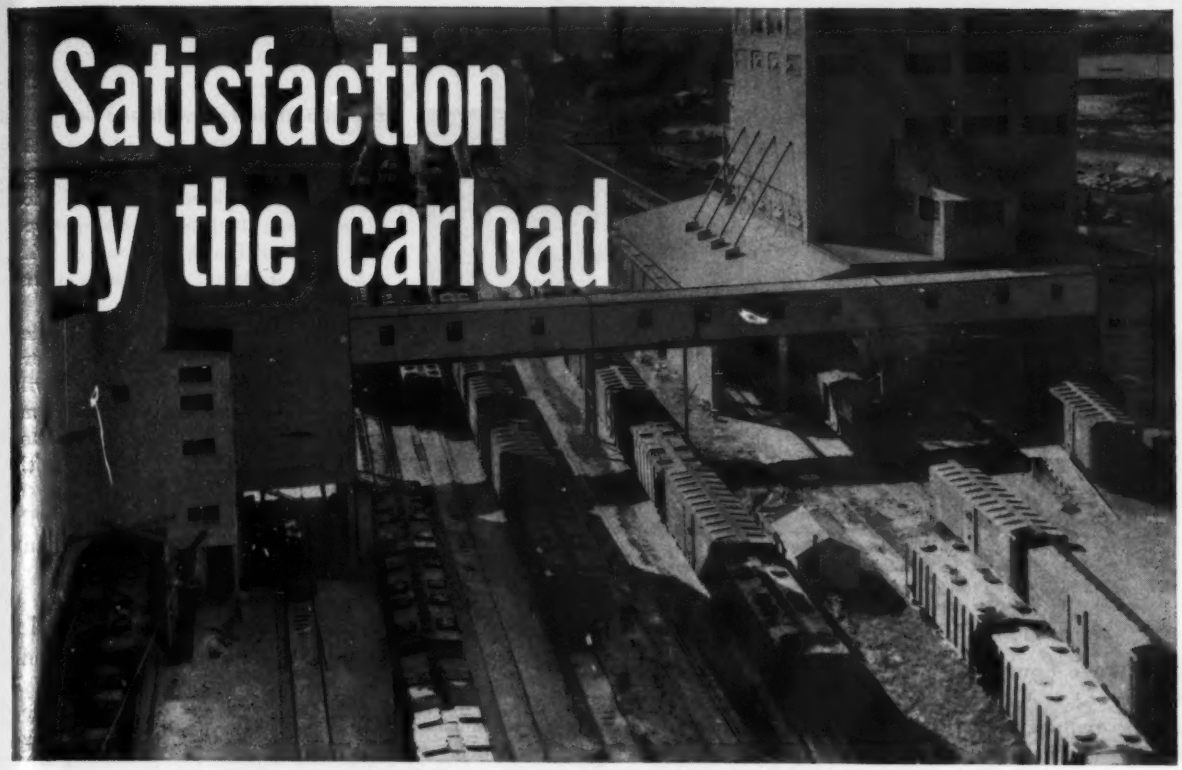
Manager of the international division, Fischer & Porter Co.

George B. Saviers

Manager, newly-established special products group, Westinghouse Electric Corp. lamp division, with responsibility for marketing products such as ultraviolet and quartz heat lamps that fall outside the scope of the company's regular field selling organization. He will have his office at division headquarters, Bloomfield, N. J., where he will report to Gordon W. Howson, marketing manager, large lamp department.

(Howson was erroneously named as special products manager, page 41, THE GLASS INDUSTRY, *January 1961.)*

Satisfaction by the carload



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Since 1900, customer satisfaction has commanded top priority here at Ottawa Silica Company. Uniformity and quality are bywords. Periodical expansion of plant facilities has maintained output at high levels. In keeping pace with growing industrial demand, Ottawa Silica Company over the last half century has become the nation's foremost supplier of silica.

Whether you order a bag or a carload, you are assured of the same steady quality that has earned for Ottawa silica, the distinction of being the world's finest.

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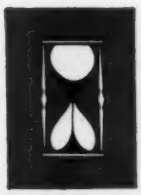


OTTAWA SILICA COMPANY
OTTAWA, ILLINOIS

SUBSIDIARY PLANTS:

Standard Silica Co. Ottawa, Ill.	Connecticut Silica Co. Mystic, Conn.
Michigan Silica Co. Rockwood, Mich.	Crystal Silica Co. Oceanside, Calif.

SERVING THE FOUNDRY, GLASS, CERAMIC AND CHEMICAL INDUSTRIES FOR OVER 50 YEARS

Ernest M. Hommel (left), president of The O. Hommel Co., presented service awards at a recent company dinner to 24 veteran employees, including (left to right) William T. Campbell (25 years), Edward J. Feeney (25 years), Nonie Cunningham (20 years), and Paul D. Henry (25 years). The annual ceremony marked the 24th consecutive year of service recognition, a custom begun by Hommel's father and founder of the firm, Oscar Hommel, in 1936.

New Wage Contract

Corning Glass Works recently signed a new contract with the American Flint Glass Workers' Union, amounting to a package worth more than 7½ cents per hour, with 3 cents in actual wages.

In addition to the wage increase, which is retroactive to November 28, the contract provided for liberalized vacation, insurance and pension benefits. They are effective until January 20, 1962. The agreement covers approximately 5,000 production and maintenance employees who are members of Local 1000, AFGWU, at Corning, Big Flats and Horseheads, N.Y.

Roy W. Niles, president of Local 1000, called the contract the "best in the glass industry." Leroy A. Amylon, a Corning vice president and director of industrial relations, headed the company's negotiators. He commended the union representatives "for the able and responsible manner" in which the negotiations were conducted and also declared the contract to be the best in the glass industry.

Latchford Glass Co.

Recently completed a $1,500,000 expansion program at their Los Angeles factory. Plant enlargement and the installation of up-to-date glass-making equipment are calculated to increase production, improve service, and lend greater flexibility and versatility to company operations.

Crestline Co.

Manufacturer of wood-frame windows, is planning to open an assembly plant in Ladoga, Ind., in a move to shorten its glass supply line while meeting an anticipated growth in production. (Over the past two years, Crestline has increased its use of glass by 18 per cent.) Glass previously shipped from eastern Ohio suppliers to the Wausau millwork plant, a distance of 950 mi., will now be shipped 300 mi. to central Indiana. Fabrication will continue at Wausau, with machined parts being trucked to Ladoga in knock-down form for assembly and glazing.

Consultants Bureau Enterprises

And Mezhdunarodnaya Kniga (International Book Corporation), Moscow, USSR, renewed their contract covering the translation into English of 23 major Soviet scientific journals. Earl Coleman, president, Consultants Bureau, stated that the agreement guarantees his company exclusive English-translation rights for publications in the fields of chemistry, physics, biology and medicine. In addition, the contract requires Mezhdunarodnaya Kniga to keep Consultants Bureau informed of any new scientific and technical journals published in the USSR.

Among the journals covered are: Glass and Ceramics, Automation and Remote Control, Solid State Physics, Soviet Physics - Crystallography, and Metallurgist.

International Resistance Co.

Has entered the semiconductor field with the purchase of controlling interest in North American Electronics, Inc., Lynn, Mass. Both firms have approved the sale to IRC of 51 per cent of NAE common stock in an all-cash transaction.

NAE will continue to operate independent of IRC, its present officers remaining unchanged. The board will be increased from the current 7 members to 11, with IRC holding 6 seats. NAE operates a modern plant with 25,000 sq. ft. of floor space, said to be ample to meet anticipated growth in production in 1961. Employment there is now approximately 130.

Kaiser Refractories & Chemicals

Division of Kaiser Aluminum & Chemical Sales, Inc., has established a new distribution facility in Springville, Utah, to serve customers in the Inter-Mountain region. The installation will be under the direct supervision of Arthur B. Morse, district sales manager, and Clifford Hales, local manager. A full line of fireclay specialty products and basic refractories will be provided on one-day delivery to customers in the area, and the company's property will be served by major truck lines and a Denver & Rio Grande Western Railroad five-car spur track.

FINANCIAL DATA

(End Fiscal Year)

Libbey-Owens-Ford Glass Co.

	1959	1960
Net Earnings	$ 53,745,152	$ 43,753,840
Net Sales	$306,734,077	$294,076,452

Owens-Illinois Glass Co.

	1959	1960
Net Earnings	$ 40,831,354	$ 33,187,105
Net Sales	$552,676,933	$561,042,319

Corning Glass Works

	1959	1960
Net Earnings	$ 24,335,899	$ 22,054,741
Net Sales	$201,370,386	$214,871,286

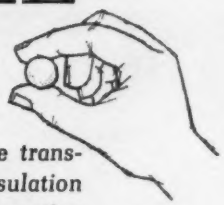
(Three Months Ended Dec. 31, 1960)

Brockway Glass Co.

	1959	1960
Net Earnings	$ 731,583	$ 269,690
Net Sales	$11,529,258	$11,718,840

MIRACLE

of fiber glass



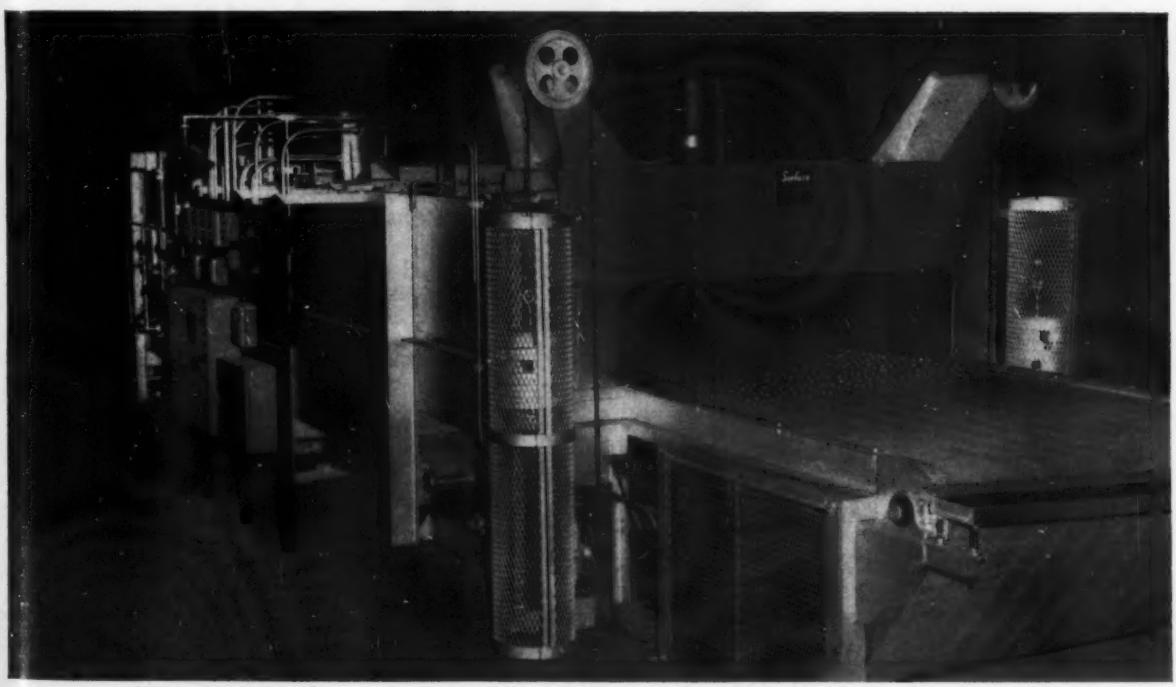
This glass "marble" is ready to be transformed into miles of fiber for insulation material. To ensure that this transformation is routine, continuous, and profitable, the manufacturer entrusts the preliminary glass annealing to Surface Combustion lehrs.

Surface delivers the necessary time-temperature cycles with remarkable precision, using either gas or electric heat with unusually high rates of air recirculation and complete zone control. These, plus Surface modular construction, are good reasons for Surface's leadership in glass processing equipment.

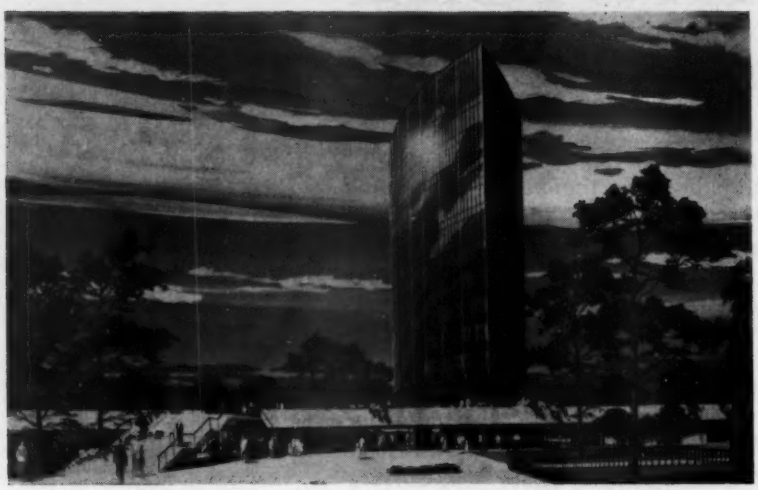
SURFACE COMBUSTION

2378 Dorr Street, Toledo 1 Ohio.

a division of Midland-Ross Corporation MR



NEW APPLICATIONS IN GLASS...



Phoenix Mutual Plans New Glass Structure

A 12-story elliptical office tower constructed of glass will dominate the new Pheonix Mutual Life Insurance Co. home office to be erected in Hartford, Conn.'s 12-acre, $40,000,000 downtown redevelopment, Constitution Plaza. Designed by Harrison & Abramovitz of New York, the building is scheduled for completion in late 1963.

The elliptical tower, first of its design in the world, will provide easy access to all offices from elevator and service areas. The one-story base will be separated from heavily traveled streets by broad landscaped plazas, and its roof will serve as a promenade looking down on a courtyard enclosing gardens and a reflecting pool. In addition to escalators connecting the ground and plaza floors and high-speed elevators serving the tower, the plans include modern, recessed lighting and year-round temperature control.

Glass: To be announced.

Glare-Free Lighting

A decorative prismatic globe has been designed for improved lighting of entrances, carports, doorways, and other areas where high levels of glare-free illumination are needed. The glass luminaire directs most of the light downward to illuminate the immediate activity area, and projects a separate widespread pattern to softly "blanket" walks, porches, and surrounding areas. This "down-and-out" distribution is maintained with 100-, 150-, or 200-watt lamps by an adjustable socket that insures identical filament location regardless of lamp size. The fixture,

available with mountings in several metal finishes, also includes two reflectors for maximum efficiency.

Glass Luminaire: Stonco Electric Products Co., 330 Monroe Ave., Kenilworth, N.Y.

Glass in Minuteman System

An improved circuit board utilizing the company's "Fotoceram" glass-ceramic has been developed by Corning Electronic Components. The boards are used in the reliability research and development program for the Minuteman missile guidance and control systems conducted by Autonetics, a division of North American Aviation, Inc.

The use of "Fotoceram," which is less lossy than fiber glass-epoxy (the original circuit board material), and a redesigned three-terminal shielded circuit allows a ten-to-one improvement in capacity measuring accuracy and meaningful measurements down almost to the level of capacitor IR and 0.05 of dissipation factor. Metallized areas in the Fotoceram, derived from photosensitive glass, can be subjected to soldering more than 50 times without damage.

An unmetallized "Fotoceram" upper board in each circuit board assembly carries 200 Corning fusion-sealed capacitors for Minuteman, and measures 6½ by 16½ by 0.070 in. Leads extend through it to a Fotoceram lower board, one inch wider than the upper board, which carries the circuit pattern. Manufactured in the thousands, these boards are the largest Fotoceram articles made by Corning.

Glass: Corning Glass Works, Corning, N. Y.

CATALOGS RECEIVED

Sliding glass doors. (7 pages) Five doors of modern line are illustrated. Includes complete specifications and data on accessories, deliveries, glazing, standard and special hardware, and special sizes available.

Ador Corp., 2345 W. Commonwealth Ave., Fullerton, Calif.

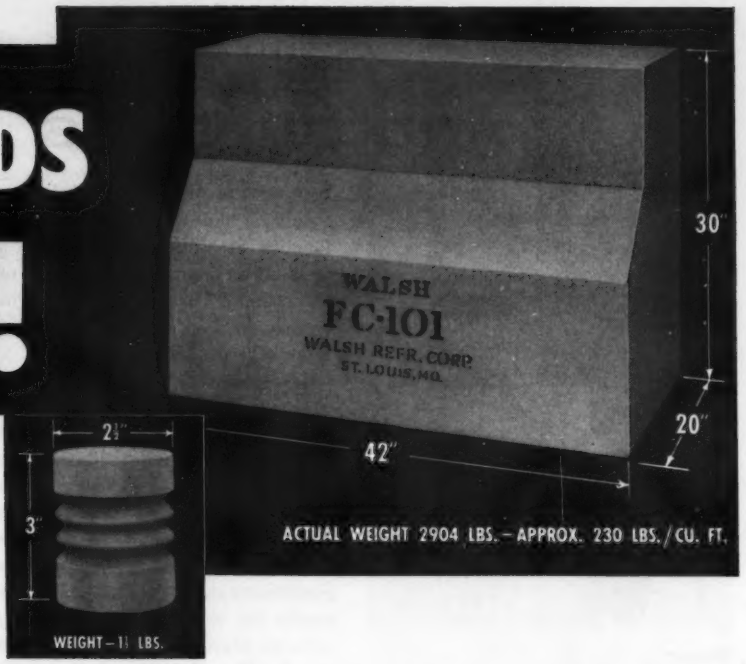
Curtain wall. (11 pages) Color-in-the-glass units in both clear and prismatic "Thinlite" glass tile panels. Recent improvements to facilitate erection and installation are shown, and illustrations and descriptions of the sizes, colors, and specification details are also included.

Kimble Glass Co., Toledo 1, O.

Insulating glass. (15 pages) Manual TP25 covers "Thermopane" insulating glass in a detailed comparison of the "Bondermetric" and "GlasSeal" types. Revised data on sound insulation values, a diagrammatic presentation of the various combinations of glass and air spaces, strength calculations, and two pages of installation pictures are included. Of special interest to architects, builders, and others planning new construction.

Libbey-Owens-Ford Glass Co., 811 Madison Ave., Toledo 1, O.

2 POUNDS OR . . . 2 TONS !



with FC-101, FUSION CAST REFRACTORY...

no shape too small . . . too large . . . too complicated

No matter what your requirements in fusion cast refractory materials, you can depend on Walsh FC-101 for the shapes that are precisely right for your particular needs. And with FC-101 you get unvarying high quality and performance features never before available . . . features that have already established FC-101 as the choice in over 150 glass plants throughout the world. To assure you of lower cost per ton of glass melted, Walsh FC-101 offers you properties that set the new quality standard, including:

- **Maximum Weight Per Cubic Foot**
- **Minimum of Voids**
- **Highest Purity**
- **Extreme Accuracy of Dimension**
- **Higher PCE**
- **Greater Spall Resistance**

Available in tilt cast or D. C. L. shapes, in sizes ranging up to 3,000 lbs. Match marking if requested.

Other WALSH Refractories for the Glass Industry

ZIRCON—analyses 99% pure zircon. Weighs approximately 220 lbs. per cu. ft. For use in bottoms of glass furnaces, as drip courses in silica crowns, burner blocks, port jambs, etc.

CAST MULLIFLUX B—Premium Quality Flux Block. Greater density, higher alumina content, more uniform expansion and superior resistance to higher temperatures and corrosion. Recommended for bottoms.

CAST FLUX—Slip Cast Flux Block. Machine ground on five faces and where necessary trued on all six faces for accuracy of dimension and ease of installation. For use under paving.

CSR—Cast Sillimanite Refractory. For safer, longer lasting protection in glass tank upper structures.

CSR FORTIFIED—Special Sillimanite Refractory. Unexcelled in upper structure "tough spots".

MULLITEX HB (High Burn) Super Duty Fire Brick. Noted for high modulus of rupture and cold crushing strength plus low porosity. Remarkable resistance to thermal shock. Withstands severe and punishing service.

MULLITEX, Super Duty Fire Brick. Excellent spalling resistance, lower porosity, good hot load bearing strength, and resistance to slag penetration.

Also, a complete line of Insulating Brick, Insulflux, glass tank insulating material, Silica Retort Patching Cement, High Alumina Refractories, Plastic Furnace Lining, High Temperature and Insulating Cements, Plastic Ramming Mixes, Wall Coatings and Refractory Castables.

Back of all Walsh products are the unsurpassed technical resources, modern facilities, and manufacturing know-how that help to keep your production costs down . . . quality high. Wire, write, or phone today.

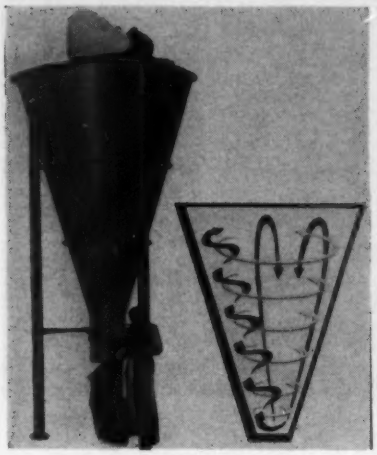
WALSH REFRACTORIES CORPORATION — America's Best Clays

WALSH REFRACTORIES CORPORATION

101 FERRY STREET • ST. LOUIS 7, MISSOURI

FOR OVER 60 YEARS THE GLASS INDUSTRY'S PARTNER IN PROGRESS

NEW EQUIPMENT AND SUPPLIES



Mixer

Has a 3-way mixing action which is said to provide more accurate control of materials being mixed, get the job done faster, and reduce heat generation to absolute minimum. A rotating screw is positioned along the wall of the conical container. As the screw revolves, it orbits around the inside wall, producing vertical and horizontal cross-currents throughout the mixer. After the material is lifted by the screw, a third mixing action occurs—when the material flows by gravity down the side of the cone, opposite the mixing screw.

The J. H. Day Company, division of the Cleveland Automatic Machine Co., has been granted the exclusive license to manufacture and sell the mixer in the United States and Canada by Nauta-Mix N. V. of Haarlem, Holland. Ask for 4-page illustrated bulletin.

The J. H. Day Co., 4232 Beech St., Cincinnati 12, O.

Dust Protection for Trucks

Gas-powered industrial lift trucks have been designed with a heavy-duty dust protection modification to reduce maintenance and lengthen engine life where atmospheric contamination is severe. In place of the standard dual air filter arrangement, this new system provides a triple filtering process which includes a dry-type precleaner, oil bath cleaner, and final dry-type filter. The heavy-duty protection also features a hydraulic system sealed against contamination.

Yale Materials Handling Div., The Yale & Towne Mfg. Co., 11,000 Roosevelt Blvd., Philadelphia 15, Pa.

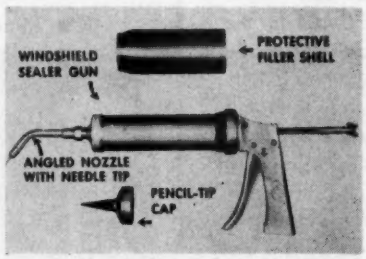
Shrinkage and Draft Calculator

In plastic slide-chart style, is available for use by draftsmen, tool, die, and mold makers, etc., in plastics and other industries. The calculator includes decimal tables, drill sizes, and other frequently used data.

Kelm Mfg. Co., Coloma, Mich.

New Windshield Sealer Gun

A curved-nose windshield sealer gun of full 8-oz. capacity has been designed to handle most viscous asphalt-type sealing compounds and adhesive sealers, even when they are cold. Positive displacement and the tight piston seal enable the gun to exhaust all of the material, leaving none to congeal in the barrel. The high pressure developed by direct rachet action forces any congealed compound from the fine needle



nose, thereby reportedly elminating the need for probing or frequent cleaning. Catalog and details are available from the manufacturer.

Vital Products Mfg. Co., 7500 Quincy Ave., Cleveland 4, O.

Air-Cooled Shaft for Fans

High-temperature fans for ovens, kilns, furnaces, and dryers are now available with an air-cooled shaft which eliminates the need for water cooling, heat slingers, and other complex cooling devices. This nickel chromium stainless steel shaft is standard on the entire line of "Thermal-Aire" fans for operating temperatures up to 1700°F. An integral chamber-and-slot arrangement reduces heat transmission, enabling the shaft to function efficiently under conditions of high speed, pressure, and temperature.

Garden City Fan and Blower Co., 801 N. Eighth St., Niles, Mich.

Improved Heating Element

A nonmetallic silicon carbide-molybdenum disilicide heating element, known as "Super Hot Rod", has been developed for use in kilns and furnaces with temperatures up to 1700°C. This new element is said to have longer life at normal maximum operating temperatures (about 1500°C), and because of excellent oxidation resistance, to raise the maximum operating temperatures about 15 per cent without losing its long life properties.

The "Super Hot Rod" is applicable in such high-temperature fields as glass melting and ceramics firing, and it makes practical certain heating operations that exceed the capacity of conventional bars. Techniques for installing and operating the rods are the same as those for other silicon carbide elements.

Refractories Div., Norton Co., Worcester 6, Mass.

Nonmetalic Resistor Furnaces

Can be equipped with tubes made of silicon carbide or alumina for zone control up to 2822°F (1550°C). The tubes range in size up to approximately 8 in. in diameter and 72 in. in length, and those of silicone carbide (up to 2 in. in diameter) can themselves serve as the resistor. These tube furnaces, adaptable for the firing of bar stock material and for gradient application, are designed for easy tube removal and replacement, and allow interchangeability of tube diameters.

Harrop Precision Furnace Co., 3470 E. Fifth Ave., Columbus 19, O.

Lineal Measuring Device

For measurement and control in yards, feet, tenths of feet, or inches. Equipped with a photoelectric sensor, it is labeled "Footage Counter", and is said to eliminate load drag inherent in mechanical counters, thereby assuring greater accuracy. Models are available with magnetically actuated pickups for applications where large amounts of dust or lint interfere with photoelectric operation.

Standard Instrument Corp., 657 Broadway, New York 12, N.Y.

Camera "Sees" Temperature

An infrared sensitive television camera that can see an object when that object reaches 850°F is now on the market, along with an ultraviolet sensitive vidicon camera which enables closed circuit TV to pick up pictures from an ultraviolet microscope. Both cameras are also sensitive to visible light, and therefore can be set up easily under ordinary lighting.

In ultraviolet microscope, using shorter wave length than visible light, can see objects so small that their diameter approaches the wave length of light, and thus, because they do not reflect light, are not visible. When a TV camera with an ultraviolet sensitive vidicon tube is attached to the microscope, the delay and expense of taking numerous photographs until the required picture is obtained are eliminated, and damage to biological specimens that would otherwise undergo excessive exposure to ultraviolet light is reduced.

Fairbanks, Morse & Co., 600 S. Michigan Ave., Chicago 5, Ill.

Reversible Work Gloves

Custom fabric "Cromac" gloves impregnated with polyvinyl chloride are now on the market in a wing thumb style that permits each glove to be worn on either hand, providing four working surfaces instead of two. Available in men's large size, the gloves come in either knit wrist or band top style, and are claimed to give excellent wearability, high finger dexterity, snag resistance, and a firm gripping surface.
Jomac Inc., Philadelphia 38, Pa.

High-Speed Disperser

Mixes, disperses, and deagglomerates products of medium or heavy paste consistency up to 60,000 centipoises in any capacity between 100 and 800 gallons. Motor drives up to 60 hp are available, and speed drives vary between 600 and 3000 rpm. The impeller on these machines is a high-impact multiple action millhead with specially machined internal chambers. Heavier duty machines center in tanks up to 6 ft. in diameter, and an automatic hydrolic cylinder permits raising from tanks up to 6 ft. deep. Complete information is available from the manufacturer.

Charles Ross & Son Co., Inc., 148-156 Classon Ave., Brooklyn 5, N.Y.

Natural Diamond Grit

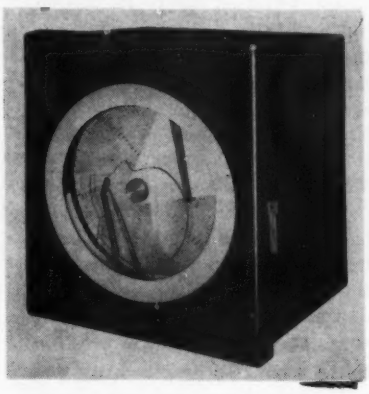
Available in Tyler screen mesh sizes of 20 to 325. Said to be especially suited for use in metal-bonded cutting and grinding tools. The smaller cube-like diamonds can be used for the cutting and grinding of glass and ultra-hard ceramics.

Diamond Research Laboraory, Johannesburg, South Africa. c/o N.W. Ayer & Son, Inc., 1271 Avenue of the Americas at 50th St., New York 20, N.Y.

New Program Controller

A round-chart cam-operated program controller designed to control in almost unlimited patterns any variable which can be resolved into a millivolt signal. This unit, which is claimed to reproduce automatically, accurately, and reliably any predetermined program, can control temperature, speed, strain, flow, etc., in various industrial processes, including glass and ceramic manufacture.

Wheelco Industrial Instruments Div., Barber-Colman Co., Rockford, Ill.



Aftercooler

Built for capacities of 50 to 120 cubic feet of free air per minute. Aftercooler is small, efficient, has no moving parts, and, according to manufacturer, requires almost no maintenance. It is designed especially for the small- to medium-sized user and features a non-corrosive copper coil through which the valve-regulated cooling water flows. The coil is attached to the flanged head with flared connections and supported throughout its length by spaced baffle plates which direct the flow of air for utmost contact with the cooling coil. Separated moisture descends by gravity to the ball float trap below where it is ejected automatically and without loss of air. Manufacturer guarantees that this unit will cool air to within 85 per cent of the cooling water temperature when installed, operated, and maintained according to instructions. Ask for Bulletin No. A4VC60.

Jas. A. Murphy & Co., Inc., 1421 East High Street, Hamilton, O.

CATALOGS RECEIVED

Dust collection and recovery systems. (4 pages) Describes complete line of dust collecting, recovery, and classifying equipment. Applications for air pollution, recovery of material from waste gasses, and employee comfort are discussed. Copies available upon request.

Buell Engineering Co., Inc., 123 William St., New York 38, N.Y.

Control linkage systems. (12 pages) A revised booklet illustrating product specifications and typical linkage arrangements for control of fan damper, stoker speed, coal feeder gate, and feed pump fluid coupling. Drive and driven levers, connecting links, bearings, and shafts, cable connectors, and cable and pulley connectors are discussed. Write for brochure No. P81-5.

Bailey Meter Co., 1050 Ivanhoe Rd., Cleveland 10, O.

DC receivers. (2 pages) Illustrated product specification sheet E12-4 describes various classes of dc receivers designed to pick up signals from transducers such as thermocouples, tachometers, and pH electrodes, and to convert them to pneumatic or electric signals to drive a recorder pen. Performance characteristics of class E and F receivers, including range, accuracy, sensitivity, response, and power supply, are listed.

Bailey Meter Co., 1050 Ivanhoe Rd., Cleveland 10, O.

INVENTIONS AND INVENTORS

Annealing and Tempering

Apparatus for the Air Chilling of Bent Glass. Patent No. 2,921,411. Filed July 27, 1951 (Original application, now Patent No. 2,736,140 dated February 28, 1956. Divided and this application September 20, 1954). Issued January 19, 1960. No sheets of drawings; none reproduced. Assigned to Pittsburgh Plate Glass Company by Lloyd V. Black.

An object of the invention is to provide improved apparatus by which sheet glass units can be bent during the course of its transportation along a horizontal conveyor system.

Each mold frame with a sheet glass unit mounted thereon is transported into a furnace which is heated to proper temperature incidental to the softening of glass, for example, to approximately 1050°F.

Each glass supporting mold is transported between groups of jet blowers at which time the conveyor rolls supporting the mold frame can be stopped for a measured time interval sufficiently long to permit application of chilling air jets upon the surfaces of the glass.

The glass supporting mold is held in proper position between the groups of oscillating jets until the glass becomes case hardened or tempered. Then the conveyor mechanism is operated to move the glass-supporting mold forward a predetermined distance to bring it between groups of jet producing nozzles in a cooling unit which merely operates to reduce the temperature of the glass. The glass still retains considerable heat although it had been reduced below the critical annealing temperature by the tempering apparatus.

Each sheet glass unit, therefore, is first subjected to a chilling or tempering treatment and then to two treatments of cooling air from two stationary jet producing units.

There were 5 claims and 11 references.

Feeding and Forming

Operating Mechanism for Glass Feeders. Patent No. 2,950,571. Filed April 12, 1957. Issued August 30, 1960. Seven sheets of drawings; none reproduced. Assigned to Emhart Manufacturing Company by Frederick J. Wythe. .

This invention relates to improvements in glass feeders for producing charges of molten glass of predetermined weights and shapes appropriate for the molds of associate forming machines.

The invention provides an electrically responsive pressure fluid motor means, preferably hydraulic, mechanically connected to the feeder plunger operatively to support and reciprocate the latter in relation to the orifice or orifices at the bottom of the spout outlet passage. An electromechanical control mechanism, which, together with a housing or case therefore, may be termed the "mechanism box" of the feeder, is linked electrically to an electronic amplifier which in turn is connected electrically with the electrically responsive pressure fluid means. The mechanism box includes a synchro receiver having a synchronized driven connection with a synchro transmitter. The synchro transmitter may be driven from a rotating shaft of the forming machine that is to be served by the feeder.

The synchro receiver acts through suitable motion transmitting means to drive an electromechanical transducer, which produces a basic electrical signal related to a desired plunger motion and being equivalent at any given instant to the desired plunger position.

The feeder shear mechanism is also an electrically responsive pressure fluid (hydraulic) operated mechanism, and the mechanism box may include means operated by the synchro receiver to produce suitably timed electrical impulses, which are fed to the shear mechanism to provide the desired glass cutting operations.

There were 17 claims and the following references.

United States Patents

1,941,552, Henry et al., Jan. 2, 19[illegible]4; 2,010,777, Grotta, Aug. 6, 1935; 2,2[illegible]4,349, MacKay, Mar. 11, 1941; 2,246,4[illegible]1, Cannon, June 17, 1941; 2,306,789, [illegible]c-Namara, Dec. 29, 1942; and 2,390,4[illegible]3, Roters, Dec. 4, 1945.

Furnaces

Method of Installing Furnace El[illegible]ctrode. Patent No. 2,953,613. Filed Or[illegible]g-inal Application December 28, 19[illegible]6, Ser. No. 631,112. Divided and this [illegible]p-plication November 14, 1958, Ser. [illegible]o. 774,033. Issued September 20, 19[illegible]0. Two Drawings; none reproduced. [illegible]s-signed to Owens-Illinois Glass Co[illegible]n-pany by George E. Keefer.

This invention relates to installation of furnace electrodes in a side or bottom wall aperture of an electric melting furnace, primarily designed for use in melting glass in which the heating effect on the glass, or batch materials, in the furnace is secured by the resistance of the material to the passage of current, and more particularly to a method of electrode installation, which installation eliminates oxidation or burn-off damage to the electrode.

Certain electrodes have the disadvantage of tending to burn-off or oxidize within the furnace wall through which they extend. Electrodes are water cooled at their furnace wall juncture to cool the electrode portion most susceptible to oxidation. The electrode cooling water, after discharge into the electrode, is not easily controlled and frequently spills onto the refractories, steel structure and walkways around the furnace. Also, as is often the case with these cooling devices, the water discharged onto the electrode evaporates in the electrode holder causing deposits of solids in the cooling system which will gradually close off circulation of the coolant water.

(*Continued on page* 168)

CURRENT STATISTICAL POSITION OF GLASS

Employment in the glass industry during November, 1960, was as follows: *Flat Glass*: a preliminary figure of 25,400 for November, 1960, indicates a decrease of 3. per cent under the adjusted figure of 26,400 for October, 1960. *Glass and Glassware, Pressed and Blown*: a decrease of 2.1 per cent is shown by the preliminary figure of 87,700 reported for November, 1960, when compared with the adjusted figure of 89,600 reported for October, 1960. *Glass Products Made of Purchased Glass*: the preliminary figure of 14,300 given for November, 1960, is 2.1 per cent over the adjusted figure of 14,200 reported for October, 1960.

Payrolls in the glass industry during November, 1960, were as follows: *Flat Glass*: a decrease of 3.4 per cent is shown in the preliminary $14,757,704.04 given for November, 1960, when compared with October's $15,289,527.79. *Glass and Glassware, Pressed and Blown*: a decrease of 1.4 per cent is shown in the preliminary $35,416,382.12 given for November, 1960, when compared with the previous month's adjusted $35,939,080.58. *Glass Products Made of Purchased Glass*: a preliminary figure of $4,914,817.91 was reported for November, 1960. This is an increase of 0.1 per cent when compared with the adjusted figure of $4,906,912.26 for October, 1960.

Glass Container Production based on figures released by the Bureau of the Census, Industry Division, was 11,195,000 gross during December, 1960. This is a decrease of 1.9 per cent under the previous month's production figure, 11,415,000 gross. During December, 1959 glass container production was 11,310,000 gross, or 1.0 per cent over the December, 1960 figure. At the end of the complete year of 1960, glass container manufacturers have produced a preliminary total of 159,940,000 gross. This is 3.8 per cent more than the 153,993,000 gross produced during the same period in 1959.

Glass Container Shipments during December, 1960, came to 11,398,000 gross, a decrease of 2.6 per cent under November, 1960, which totaled 11,706,000 gross. Shipments during December, 1959, amounted to 10,690,000 gross or 6.2 per cent under December, 1960. At the end of the complete year of 1960, shipments have reached a preliminary total of 156,347,000 gross which is 2.3 per cent more than the 152,690,000 gross shipped during the same period of the previous year.

Stocks on hand at the end of December, 1960, came to 20,402,000 gross. This is 1.1 per cent under the 20,622,000 gross on hand at the end of November, 1960, and 17.8 per cent more than the 17,312,000 gross on hand at the end of December, 1959.

GLASS CONTAINER SHIPMENTS
(All Figures in Gross)

Narrow Neck Containers

	December, 1960
Food	981,000
Medicinal and Health Supplies	1,276,000
Chemical, Household and Industrial	789,000
Toiletries and Cosmetics	735,000
Beverage, Returnable	805,000
Beverage, Non-returnable	160,000
Beer, Returnable	182,000
Beer, Non-returnable	1,091,000
Liquor	691,000
Wine	432,000
Sub-total (Narrow)	7,143,000

Wide Mouth Containers

Food	*3,211,000
Medicinal and Health Supplies	354,000
Chemical, Household and Industrial	121,000
Toiletries and Cosmetics	266,000
Dairy Products	178,000
Sub-total (Wide)	*4,130,000
Total Domestic	11,272,000
Export Shipments	*126,000
TOTAL SHIPMENTS	*11,398,000

* This figure includes Fruit Jars, Jelly Glasses, and Packers' Tumblers.

GLASS CONTAINER PRODUCTION AND INVENTORY
(All Figures in Gross)

		Production December 1960	Stocks December 1960
Food, Medicinal and Health Supplies; Chemical, Household and Industrial; Toiletries and Cosmetics.	Narrow Neck	3,791,000	6,911,000
	Wide Mouth	*3,981,000	*6,694,000
Beverage, Returnable		613,000	2,204,000
Beverage, Non-returnable		175,000	350,000
Beer, Returnable		188,000	494,000
Beer, Non-returnable		1,161,000	1,186,000
Liquor		703,000	1,555,000
Wine		422,000	731,000
Dairy Products		161,000	277,000
TOTAL		*11,191,000	*20,402,000

* This figure includes Fruit Jars, Jelly Glasses, and Packers' Tumblers.

PROPERTIES OF SAFETY GLASS

(*Continued from page* 121)

ation committee on glazing materials, described the development of the tests prescribed by the code. He performed actual demonstrations using steel balls, pointed darts and heavy shot bags to show why each material has to have a special set of tests to determine whether it is properly manufactured.

Ormund Rugg, Glass Engineer for Ford Motor Company, discussed the quality control aspects of manufacturing laminated and tempered glass and provided demonstrations of non-destructive polariscopic examination of tempered glass used to guarantee that each piece has been tempered, and also broke both tempered and laminated glass to show resultant safety fracture patterns as compared with ordinary glass. Mr. Rugg pointed out that in many respects, quality control is simpler with the use of tempered glass, and safety records have been proving that high quality levels are maintained.

Mr. Laurence Keim then performed several tests that have been suggested by persons promoting laminated or tempered glass to show how results of tests can be slanted to convey the impression desired by the demonstrators. A so-called edge sensitivity of tempered glass was refuted by Mr. Keim by actually striking a piece of tempered glass on an exposed edge forty times with a metal screw driver, chipping away glass and creating sparks with each blow—but requiring a hammer blow to shatter it.

At this point a movie condensing the extensive study that preceded the Ford Motor Company decision to use tempered safety glass in side lites of its vehicles was shown. Careful measurements of relative speeds required to cause irreparable damage to a simulated human head in the event of an accident, and the conclusive evidence that tempered glass does not "explode" upon disintegration, were factors that resulted in the decision that tempered glass as used in the Ford automobiles was no compromise with safety, but a bonus in safety. This was compared with evidence gathered from the use of tempered glass in identical vehicles in Canada.

Mr. Howard Gandelot, Safety Engineer for General Motors, narrated a typical test track film in which actual crash conditions of a current model car were photographed. In all cases of severe body deformation, including roll-over tests, the conclusion was that tempered glass, which was being used in the model being tested, received a stamp of approval for performance in protecting the dummy passengers and remaining intact under adverse conditions.

Mr. Richards, in summary, pointed out that he hoped all responsible parties would benefit from the knowledge that much work, years of testing and careful analysis had gone into the decision of the motor car manufac-

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turers to use tempered safety glass in side lites of their cars, just as they have been using it for more than twenty years in the rear window, and that sporadic attempts by commercially biased groups to restrict its use, even at the expense of sacrificing the tremendous advantages that uniform motor vehicle legislation provides to all citizens, would receive very intelligent scrutiny before inadvertent legislative action can cause serious damage. He pointed out that, by admission of the dissenters themselves, tempered safety glass is broken less than 1/10 as frequently as laminated glass. This he said naturally results not only in lower replacement business volume, but also in lower cost to car owners and provides a greater safety factor.

Questions from the audience were answered by members of the panel. In conclusion, Mr. Richards, on behalf of the participating experts and executives, expressed appreciation to the Federal Safety Council and its officers for making it possible for so many interested and concerned individuals and departments to gather for this program in an important, though little-recognized field of safety.

1961 BLEININGER AWARD

(*Continued from page* 122)

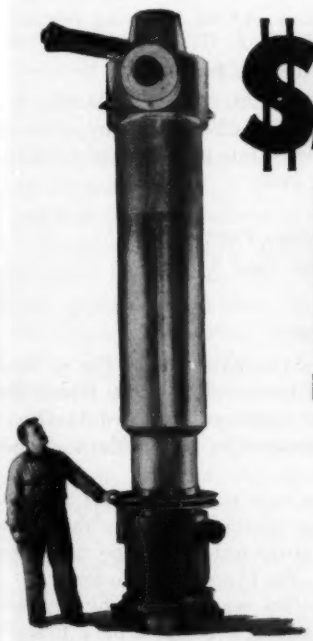
A former associate, Dr. J. T. Littleton, honorary vice-president and retired director of research and development for Corning Glass Works, wrote in 1940*:

"When Sullivan entered the glass industry, research in glass was in its infancy. The problem he faced was not merely that of devising useful new glass compositions. The glass often had to be manufactured by radically new methods and, except in those cases where it was created to fill a need already well realized, new markets had to be discovered. New glasses meant new uses for glass. These outlets for the Sullivan glasses were mostly in industrial fields where their special properties fitted them for special uses, and consequently they are called technical glasses to distinguish them from the common glasses in domestic use. As created by Sullivan, this business of making such glasses, initially almost nothing, is now the largest of its kind anywhere in the world. Truly a remarkable fruition of a research idea."

"Beyond his reputation gained as an organizer and executive, Dr. Sullivan is best known for the development of low-expansion glasses of great durability and of low-expansion or heat-shock-resisting signal color glasses. The Pyrex chemical glassware and cooking utensils are an example of the former, and the standard railroad signal color glass, of the latter.

"Dr. Sullivan has made many acquaintances and strong friendships dating to his college days as student

*News Edition, American Chemical Society, 18 (1940) p. 821.



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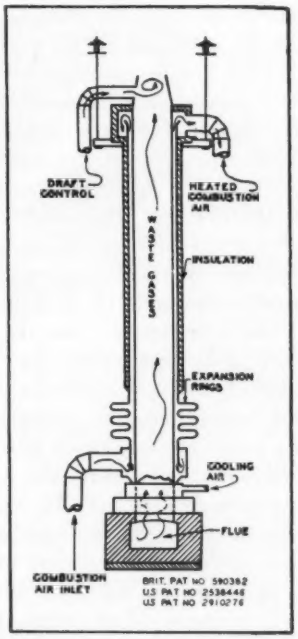

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and teacher. He was once likened to ex-President Coolidge, 'though not quite so garrulous'. That statement is not quite fair to him. His friends would say that 'he is not necessarily a man of few words, but is most positively a man avoiding unnecessary words'. . . . The same habits of thought and analysis which he applies to a research problem are applied to other situations. Sullivan was drafted into executive work. Those who know him are sure he would be happier behind a laboratory bench with some 'smelly' test tubes than behind a desk or at the head of a board room table."

In his nomination of Dr. Sullivan for the Bleininger Award in November, 1960, Dr. W. H. Armistead, vice-president and director of research and development, wrote:

"Dr. Sullivan has always been an exponent of a thorough fundamental educational training in the sciences. As can be surmised, his interest and abilities are broad but he is still primarily a scientist. He reads internal and published reports of both scientists and executives with keen interest and frequently is called upon for suggestions and advice. Because of these wide abilities in so many fields, he is highly admired and respected by factory worker, scientist, and executive alike, as well as by his many friends throughout the world. Truly a remarkable man who has in his quiet, modest way been outstanding in his contributions to the growth of the entire glass and ceramic industry."

These are heart-felt tributes from men who have known Dr. Sullivan well. A permanent physical record of his accomplishments, and of his scientific prowess, is offered by the expansion of Corning itself, which today is completing a fifth research labortory—the Eugene C. Sullivan Science Park—a notable research landmark in honor of a beloved and highly respected glass pioneer.

CONDITIONS OF GLASS FORMATION

(*Continued from page* 128)

viscosity of a chilled glass drifts with time toward an equilibrium value (H. R. Lillie[19]).

Our interpretation that the structure-controlled influence of the temperature upon the viscosity is the result of asymmetries is applicable to all glasses regardless of the composition. The formation of defects with increasing temperature and their effect upon the binding forces makes it impossible for the viscosity to follow a simple exponential function. We should not even expect a smooth curve for the logarithm of the viscosity as a function of the temperature of glasses because different types of defects will form at different energy levels.

P. Gilard, G. Henry and L. Dubrul[20] observed distinct breaks in the log η versus 1/T curves. These discontinuities in the activation energies of viscous flow have been confirmed by E. Plumat[21] who examined a large number of simple and complex glasses. Characterizing the viscosity of his glasses by the activation energy and a structural parameter which Plumat called "lattice coefficient," he found glasses with two and others with three temperature regions each of which could be described by a set of lattice coefficients and activation energies. These structural changes can be interpreted as order-disorder phenomena similar to those occurring in alloys. The properties of glasses and of single crystals of alloys depend strongly on the previous thermal treatments. This general description should not prevent us from being more specific and speak of definite atomic arrangements, e.g., alumino-silicates, if there is experimental justification for it.

In most cases there is no need for a detailed atomistic interpretation of these breaks but the investigator wants to know whether or not breaks in property temperature curves can be expected. (*To be concluded in April*)

INVENTIONS AND INVENTORS

(*Continued from page* 164)

This invention contemplates applying a sheath to the electrode in other forms than the snugly fit sleeve. The same air-tight sheath may be provided on an electrode by plating a longitudinal portion of the electrode with a metal, examples of which are chrome, nickel or silver plating applied directly to the electrode over the desired portion. Another variant for applying a sheath is spraying a coating of metallic material having properties of high oxidation resistance directly to a longitudinal portion of electrode. Examples of such metallic materials are compositions of Al-Cr-Si, Cr-Mo-Si, Mo-Ni-Si, Fe-Si-, and Ni-Si.

There were three claims and the following references.

United States Patents

2,636,914, Arbeit, Apr. 28, 1953; 2,693,498, Penberthy, Nov. 2, 1954; 2,736,759, Penberthy, Feb. 28, 1956; 2,798,892, Penberthy, July 9, 1957; and 2,802,041, Bramlett et al., Aug. 6, 1957.

Foreign Patents

692,442, Great Britain, June 3, 1953.

Glass Wool and Fiber

Treated Glass Fibers and Compositions for Use in Same. Patent No. 2,938,812. Filed April 21, 1954. Issued May 31, 1960. No sheets of drawings. Assigned to Owens-Corning Fiberglas Corporation by Alfred Marzocchi and Remus F. Caroselli.

This invention relates to a composition for use with fibers as a size, binder or coating to improve the processing and performance characteristics of the fibers and to improve the finish on the fibers in fabric form.

The desired characteristics are developed by treatment of the glass fibers to deposit a complex of a titanium ester on the glass fiber surfaces. The reaction to anchor the complex on the glass fiber surfaces is believed to be based upon the ability of the titanium ester, preferably the titanium tetraester, to form a complex compound by reaction with compounds containing hydroxy and/or amino groups and in which the hydroxy groups on the glass fiber surfaces become capable of complexing to

tie in the titanium compound onto the glass fiber surfaces.

The following represents a composition embodying features of this invention for use as a composition for treating glass fiber:

45.6 parts by weight beta-amino ethoxy titanium cocoanut acylate (2% solution)
6.8 parts by weight imidazolene stearate cationic compound
2220 parts by weight water
5 cc. acetic acid

There were 5 claims and 11 references.

Sheet and Plate Glass

Glass Polishing Compositions. Patent No. 2,955,031. Filed February 25, 1959. Issued October 4, 1960. Two sheets of drawings; none reproduced. Assigned to National Lead Company by Jerald L. Bliton and William J. Baldwin.

It has been determined that glass polishing compositions with relatively high efficiencies are obtained when the metallic monoxides ZnO, CdO, and PbO are used as additives and mixed with other known oxidic glass polishing agents. Such polishing agents include ceric oxide (CeO_2), rouge (Fe_2O_3), alumina (Al_2O_3), titania (TiO_2), stannic oxide (SnO_2), and silica (SiO_2). In many cases the polishing time required with a mixture is less than that required to obtain the same degree of

(*Continued on page* 170)

FIBER GLASS FOR AUTOMOTIVE INDUSTRY

(*Continued from page* 145)

light. Some type of phototropic material would be dispersed in the plastic for the purpose of keeping the amount of light entering the car under continuous automatic control.

Interesting lighting effects could be accomplished not only by light conduction, diffusion, and panel-glowing light bars, but also by electroluminescence of certain plastic materials containing the proper excitable salts.

The rapidly advancing electronic sciences will no doubt prove to be useful in the regulation of future automobile traffic. Fiber glass auto bodies, transparent to radar or magnetic contact, may be operated by a driver or automatic pilot, constantly guided or even controlled by electronic signals.

It is important, though, to realize that vast increases in the use of fiber glass for car bodies need not wait for revolutionary changes in power plants or transportation patterns. We have fiber glass sports cars today. We have mass-produced body components today. The great industries concerned need to devote their resources of money and imagination to further utilization of fiber glass. The inevitability of high strength glass reinforced plastic materials in future automotive design is an exciting challenge, and a unique scientific opportunity for creative designing and engineering. We are on the road to a fascinating future.

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